INDUSTRIAL MANAGEMENT

SPRIEGEL *and* LANSBURGH

INDUSTRIAL MANAGEMENT

5th Edition

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We are glad to recognize the enduring contribution of the late Richard H Lansburgh, whose first edition of 1923 set the pattern that has been preserved in this Fifth Edition of *Industrial Management* We have striven to maintain a balance between theory and practice and to have the theory an outgrowth or projection of successful practice rather than pure abstraction We have written with both the college student and the executive in mind The college student desires to learn the latest practices and theory behind them, and the executive is interested in suggestions that may help him solve his current problems Throughout the book an effort has been made to show the relationships and the interdependence of the various major departments of a business The policies and principles of successful management and the devices to carry them out are presented Without these no management, however clearly conceived, can be successful

The underlying philosophy in this book recognizes that management has a responsibility to the community, the consumers, the employees, the owners, and organized government Scientific management strives to harmonize the various interests involved in the productive process Business relationships have been treated with the belief that faith must be created in modern business—faith of the management in the employee, and faith of the employee in the management These relationships have been presented with the thought that worth-while management must be courageous and willing to lead, but must be always careful lest unprofitable experiments discourage future attempts to improve management methods

At the request of teachers using the Fourth Edition, we have added a new chapter, "Job Evaluation," to the section on wage payments Throughout the book the central purpose has been to present a unified treatise The technical sections of Chapters 10, 14, 15, and 16 are presented as general information, it is not expected that the average student will master these technical details

Sound managerial principles are universally applicable, hence the illustrations have been selected from a variety of industries In the main, the text has been developed from the point of view of the medium-sized plant, but frequent reference has been made to the large and to the small enterprise Since the basic principles and policies which have been laid down are applicable everywhere, only the systems and devices which put them into effect need be modified as the size of the plant changes

We are indebted to a large number of business firms for furnishing the illustrations used in the book and for providing technical information. We are deeply appreciative of the continued interest and help over the years of Professors Myron L. Begeman of the University of Texas, Charles B. Gordy of the University of Michigan, W. F. Spafford of Rensselaer Polytechnic Institute, and Adolph Langsner and H. Barrett Rogers of Northwestern University for their counsel and criticisms. Professor Claude George and Clark Myers of the University of Texas have been especially helpful by reading certain chapters and making constructive suggestions. I am also appreciative of the work of my wife in the preparation of the manuscript.

WILLIAM R. SPRIEGEL

Austin, Texas
January, 1955

PREFACE TO THE FIRST EDITION

With the confident judgment that in careful analysis of management problems is to be found the hope of industry, this book has been developed Stress has been placed on general organization problems, not only in the chapters on organization, but throughout the text, with the deep conviction that if a satisfactory structure be developed for any enterprise, all other phases of management are simplified

With the hope of stressing the fundamentals of sound management, which must be developed prior to granting attention to more spectacular phases, a number of chapters have been devoted to the background of present-day management policies, to organization as an abstract consideration, and too often-unappreciated standardization work Throughout, the effort has been made to show the relationships of each major portion of the business to the others and the interdependence of the various major departments Policies and principles of successful management form the background, into which are fitted the devices to carry them into effect, without which no management, however highly conceived, may be successful

Operations have been treated with the belief that faith must be created in modern business, faith of the management in the employee, and faith of the employee in the management They have been described with the thought that worthwhile management must be courageous, must be willing to lead, but must be always careful lest unprofitable experiments discourage future attempts to improve management methods

The examples and illustrations have been chosen from a diverse group of industries in the hope of insuring that good management be looked upon as universally applicable At the same time they have been chosen from the standpoint of best explaining the problem at hand Illustrations have been taken from particular plants, wherever practicable, but necessarily, for clarity and to reach fundamentals, applications have at times been made to insure full understanding of the general principles In the main, the text has been developed from the point of view of the medium-sized plant, but frequent reference has been made to the large and the small enterprise Such basic principles and policies as have been laid down are applicable everywhere, and only the systems and devices which carry them into effect must be modified as the size of the plant changes

In brief, this book aims to present a co-ordinated, simple treatment of the problems, the ideals, and the methods of successful industrial management in a way which is at the same time broad and specific, and which aims to indicate the responsibilities of the factory executives to the workers, the stockholders, and the community

During the preparation of this book, over a period of several years, the constant help and advice of numerous industrial executives has made possible the presentation of much of the material which is included The author wishes to express especial appreciation of the aid received from Mr Percy S Brown, Works Manager of the Corona Typewriter Company, Mr George Comfort, Works Manager of the Miller Lock Company, Mr James M Ketch of the National Lamp Works, and Mr H K Hathaway, Consulting Engineer in Management Mr Charles B Gordy, Assistant Professor of Mechanical Engineering, University of Michigan, and Mr John S Keir, Professor of Industrial Economics, Carnegie Institute of Technology, have also rendered criticisms and comments which have materially assisted in developing the text During the preparation of the book continual constructive comment and criticism, and, indeed suggestions for rearrangement of material, as well as much of the material itself, have been received from the following, who are or have been instructors in the Department of Industry of the Wharton School of Finance and Commerce of the University of Pennsylvania Messrs Robert P Brecht, John W Carter, Leon Henderson, Victor S Karabasz, Francis P O'Hara, Norris M Perris, Theodore R Snyder, and Morton S Whitehill For reading the completed manuscript and making numerous valuable comments thereon, the author is very grateful to Professor Erwin H Schell, of the Massachusetts Institute of Technology He wishes to express his deep appreciation of the aid received from all these sources, to which such features of this text as may be valuable are largely due

RICHARD H LANSBURGH

Philadelphia, Pa
July, 1923

Part 6 Wage Payments Basic Relations of Employers and Employees

Part 7 Buying, Selling, and Cost Controls

Part 8 Material and Production Control

Part 9 Personnel Administration and Management (Industrial Relations)

1 THE HISTORICAL BACKGROUND OF MODERN INDUSTRY

Industrial management Industry is used in this book primarily in its broadest sense to include not only the production of goods but also the various processes involved in getting the goods into the hands of the ultimate consumer Although most of the illustrations come from companies that both manufacture and sell, the viewpoint is that of the broader managerial function Scientific management has had its greatest development in such companies Banks, retail establishments, transportation companies, and all businesses have also used scientific methods but, taken collectively, to a lesser degree than manufacturing

The evolution of the modern factory On the frontiers of civilization, *domestic production,* or production in the household for the use of its members, has always been present Domestic production implies essentially an absence of exchange and the ability of each household to satisfy the wants of its members by its own labor *Handicraft production,* or "custom production," characterized the period prior to our present system Sales in the handicraft production system tended to be local The development of handicraft production was accompanied by the growth of guilds, or associations of workers in the same trade, banded together to promote their mutual interests The growth of a particular guild in a town often caused that town to become the center of a certain type of manufacturing, and the guild in time came to control the town government as well as its trade There was no large class of wage workers under the guild system, but each worker, having passed through his years of apprenticeship, could become a master of the craft During the period of the guilds the entrepreneur began to make his appearance in industry The master worker or merchant who had accumulated some capital bought raw material and distributed it to workers, later collecting and distributing the finished product, either directly to consumers or to merchants In the sixteenth, seventeenth, and early eighteenth centuries this method prevailed in the manufacture of staple commodities and became the forerunner of the factory system As a result of this plan the era came to be called the "cottage period" of industry, since so much of the work was done in cottages just outside of towns

The workers still owned the tools of production, but the contact with consumers of their product was made for them by merchants The growth in size of certain individual enterprises parallel the "cottage period" In Germany just before 1800 there were at least 20 establishments, each employing between 100 and 500 persons These factories were essentially an extension or outgrowth of the domestic system of production They existed side by side with the handicraft system Specialization of labor took place to a limited extent Even without the Industrial Revolution, it is highly probable that these factories would have continued to grow and in part at least would have replaced the domestic system [1]

In England James Hargreaves' spinning jenny, patented in 1770 but in use several years before that date, was the first machine to spin yarn It was improved upon in 1771 by Richard Arkwright, who invented what he termed a "water frame" In 1779 Samuel Crompton constructed his "mule," so called because its construction embodied features of both earlier inventions This device increased the potential production of yarn beyond the ability of the weavers to make it into finished fabric This condition was directly contrary to that prevailing before the invention of Hargreaves' jenny, when the use of a "fly-shuttle" (practically a hand device) had given weavers a capacity for work that could not be met by the spinners By this time, however, the invention of textile machinery had gained a fair start, and the need was met in 1785 by the fourth great invention, Edmund Cartwright's power loom These inventions served, within comparatively few years, to revolutionize the textile industry—the industry which, possibly more than any other, is closely interwoven with human wants and human progress—and to place it on a machine basis With the invention of the steam engine by James Watt and its adaptation to factory work in the closing years of the century industry broke away from the hampering limitations of water power, and the real Industrial Revolution began

Watt's engine provided power but there still remained the need for a better method of producing the machines that were to use the steam power The slide rest for accurately guiding cutting tools, the turret, and the combination of these two elements into the automatic lathe by Christopher M Spencer of Connecticut were the epoch-making improvements in machine-tool construction, and they were all made about this time It would be difficult to overemphasize the importance of these metalworking tools They can be and are frequently used in mass production, but they are essentially general-purpose machines in contrast to special-purpose production machines The machine tools are used in making the production type

[1] See Dexter S Kimball and Dexter S Kimball, Jr, *Principles of Industrial Organization*, 5th Edition, McGraw-Hill, New York, 1947, p 8

of machines Motors, pumps, generators, and special-purpose high-production machines are produced with the precision type of machine tool Watt, for example, was thoroughly familiar with the principles of his steam engine long before he was able to build a production engine He was forced to wait more than a decade before a boring machine was devised to turn the cylinder with sufficiently accurate dimensions from the bottom to the top

The Industrial Revolution Prior to the establishment of the first cotton factory in 1790 the early colonies were exclusively agricultural The difference between England and the early days of the United States was that England was primarily an industrial country, whereas there was but little manufacturing in the United States The immediate effect on the social and economic life of the people in America therefore was less marked The essence of the Industrial Revolution was the transfer of skill from the worker to the machine plus the creation of the machines themselves Since the transfer of skill involves, at least temporarily, loss of earning power for the particular workers involved, it is not hard to account for the frequent opposition of workmen to the introduction of new machinery The skilled worker found himself *degraded* in many cases to the level of unskilled girls and boys, who could operate the new machines The degrading effect of transferring skill from the worker to the machine was not permanent for the working class as a whole Large groups of workers were soon needed to produce the machines with which the others worked, and this, together with the general expansion of industry, afforded increasing employment for skilled men Frequently, however, the individual suffered, as did the skilled weaver, whose place was taken by the automatic loom, the skilled work was largely done by the metal worker, in an entirely different trade The result was the economic degrading of the displaced skilled worker and an increase in the number of skilled workers required for the manufacture and servicing of the tools and equipment, making a net gain to society as a whole, but a distinct loss to the group displaced

The process just described has been going on in the United States even up to the present One of the phenomenal changes of the past 20 years has been the increased earnings of the semiskilled worker in relation to the skilled worker and even the supervisors of all workers The progressive tax structure has caused the leveling effect upon the supervisors, but the wages earned by the semiskilled workers have been largely the working out of the supply and demand factors plus the increased productivity of the semiskilled workers when equipped with the present-day tools The average worker today in the metalworking industry uses approximately $10,000 worth of equipment, including, of course, the cost of the building and

inventory of goods This is a far cry from the days of the worker with hand tools

The present status of workers has not been achieved without opposition We have featherbedding on the railroads and restriction of production in many areas Possibly the building trades give our best illustration of this restriction of production This is not new in any sense of the word A mob of spinners wrecked the first machine built by Hargreaves An early American illustration of the opposition of vested interests of workmen to the introduction of new equipment and methods is significant When the West was first being opened, materials and supplies were transported across the mountains from Virginia and North Carolina into Kentucky by pack trains of horses and mules This was a slow and expensive method Soon the trails were widened, and wagon trains began to move westward The pack-train drivers opposed this method and rolled stones down the mountain sides to destroy the wagon trains and the new roads Opposition to the introduction of new devices may be directed toward machinery which itself increases output or absorbs workers' skill However, it often has been directed toward devices or management methods which study processes or measure output in order that management may know better how quickly work should be done

The foundations of American business Few people realize the long, slow, pedestrian growth of business in the United States It is astounding to talk with young men from many parts of the world who are so anxious to have someone (not themselves) build for them plants in their countries similar to our large industrial plants They little realize that industrialization is a coordinated process if the economy is to be a healthful one They want to start where we are without going through the intervening steps of a balanced growth Our foreign friends could make use of European workers or our skilled workers but start on a small scale The early American period was characterized by small factories with relatively narrow markets As a basis for its early growth American manufacture had the transplating of European industry, almost bodily, to the shores of this country European workmen, European machinery, frequently European superintendence, and even European raw materials formed the entire groundwork for the establishment of our early manufacturing

In our early history a financial group arose whose business it became to provide the means of carrying on the rapidly increasing transactions between these newly established groups of industrial society The larger the competitive area over which a product was distributed the more necessary became the services of the financier, thus his growth to a dominating position in industry followed the increasing development of markets

We are prone to think of the early business days in our country as ones in which labor-management peace prevailed Despite the opportunity of personal contact in the early days of American industry, labor troubles were numerous and could hardly be called less violent than those experienced today They were, however, sporadic and unorganized Strikes occurred, many being caused by the attempt to abolish in manufacturing the long hours of agriculture It was many years before the 10-hour day became common The governing philosophy of modern management had not even caught a foothold in the industry of the time There were many attempts to form labor organizations, some of which were successful for a time, but there were no national union organizations

Industrial growth It is seldom recalled how rapidly industry grew during the nineteenth century and the phenomenal growth of the first 25 years of the twentieth century The growth during the second 25 years of the twentieth century has merely been a natural evolution for the progress made up to this time During the period of the great industrial expansion the United States rose from the position of a novice among nations in manufacturing to the position of the greatest manufacturing nation in the world Not only was the home market larger because of the unsatisfied wants of a growing population, but also the size of this market was important from a political and geographical standpoint Business flowed freely, unhampered by tariffs and other barriers, from Maine to California and from Puget Sound to Florida If NATO could only bring a large part of the economic advantages we enjoy to the countries of Europe they would be on the verge of their greatest development

With the growth of industry and wider markets, increased division of labor made possible further construction of machines to perform the simplified operations creating a reciprocal relationship Thus the spiral of simplification of operations and machine development continued The two factors became both cause and effect when looked at from different points of view in the cycle of development of production equipment Transfer of skill to machines made possible the reduction of manufacturing costs, bringing wider markets that made possible increased production Increased volume of production encouraged simplification of operations and justified expenditures for further mechanization

Today we are talking about harnessing atomic energy and space ships This is a far cry from Watt's steam engine In predicting the future we must never forget that the present rests on the wide use of the electric power now available Invention during the second period of American manufacture founded great new industries, filling new wants and creating whole new markets The use of electricity for power, communication, and light created within the last three-quarters of a century one of the great

basic industries Within the last 50 years the successful use of the gasoline engine for transportation purposes has given the United States the automobile industry, one of its truly great enterprises The beginnings of all these industries, the refinements in manufacturing technique, and the improvement in product which followed and broadened the market for each are all characteristic of the second period in American manufacturing It should ever be remembered that this growth was a balanced growth, not one in which one area advanced all out of proportion to other activities

Probably the introduction of interchangeable parts is the key to large-scale modern industry (assuming of course the large market which is ours) Eli Whitney is known to every sixth-grade American schoolboy as the famous inventor of the cotton gin, but few persons know that his greatest contribution to modern industrial practice was the introduction of the manufacture of standardized interchangeable parts American manufacturing developed so rapidly, under conditions entirely different from those of Europe, that it soon found itself practically free from the bonds of European influence

Refinements following the phenomenal period of expansion The second quarter of the twentieth century was one of consolidation and refinement of established techniques and discoveries It is true that certain new developments and discoveries were made during this period, such as the various antibiotics in medicine and nylon and other synthetic fabrics, and atomic energy was in part released, but these developments will have greater influence upon the next 25 years than they have had during the quarter of the century when they were developed This last period of industrial evolution in industry in the United States was one of refining the scientific methodology that came into being during the early part of the century Many companies began to direct attention to economies in production and accurate cost-finding methods that gave them an advantage in the establishment of selling prices The scientific industrial age began to arise out of the changed conditions Attention to methods of operation is the outstanding feature of this era Possible methods of saving through more effective factory operation were considered, thrashed over in executives' meetings, and adopted as a part of plant policy

During the twenties consolidations were common in industry It is true that some consolidations took place later, but the period from 1925 until the present has been one of growth within established companies and the establishment of new companies rather than one of extensive mergers This growth in the size of operating companies called for new techniques for efficient operation and control Such organizations imply control of many plants through operating or managing representatives of the owners, financial representatives, sales representatives, and production representa-

tives In this organization lies an additional reason for attention to operating methods

The evolution of the professional manager With the passing of the great captains of industry large-scale business is in the hands of hired managers During the past 20 years the ownership of the voting stock of our large corporations has undergone a marked change Stocks have become widely distributed At the end of 1953 the General Motors Corporation, according to its annual report, had 494,632 individual stockholders Only three men own as much as 1 per cent of the stock of this great corporation and each of them is past 70 years of age It is evident that even 1 per cent of the stockholders of General Motors would find it difficult to voice their desires at an annual meeting As a matter of general practice most stockholders give proxies to some member of the top management, thus tending to perpetuate a given management in power This trend in administrative and managerial structure is an outgrowth of the third period in the development of American industry It has brought into existence the professional manager with pressure from the outside for dividends The real owners of our industries are relatively silent in their management and administration This situation raises new problems and makes it imperative that there be a profession of management that is truly scientific, with deep-rooted traditions of social justice to all Fortunately the present manager of large-scale business is professional in his approach and his successor will be even more so

The effect of war on industrial development No one would want the tragedies of war in order to secure industrial progress The fact remains that under the necessities of war rapid strides were made toward industrial efficiency Habits formed in World War I carried over into peacetime operation It would be unusual indeed to find an industry making war supplies that did not have its peacetime methods changed through being forced out of the well-worn ruts of years of routine operation There came into the concepts of both employer and employee an increasing sense of the importance of the individual worker to industry Whereas before the war the emphasis in managerial matters was placed largely on the physical aspects of management, such as plant, equipment, and materials, after World War I attention was directed equally to the human element A fundamental change in attitude on the part of the directors of industry developed

World War II exerted even a greater influence upon the introduction of scientific management than did World War I Hundreds of new plants were built which required (1) organization structure, (2) training of executives, supervisors, and workers, (3) plant layout, material handling, and special-purpose equipment, (4) production control, (5) material control

and storage, (6) purchasing, (7) packaging and shipping, (8) motion and time study, and (9) personnel management and administration. Tremendous strides were made in all these fields. Very few strictly new developments were made in the field of management, but establishd principles were given a wide field for tryout and use. More people, both workers and management, became conscious of the possibilities of scientific management than ever before.

Unionization of workers increased tremendously during both World Wars, and management strove to develop procedures and techniques to make its relationship with unions a success. Today unions are no longer weak, in their collective strength they are frequently stronger than the individual employer or employer group. In all probability the next big problem to be solved is the protection of public interest from the results of unnecessary industrial strife. During World War II it was clearly demonstrated that real collective bargaining is not engaged in when either side thinks that it can appeal to the government and thereby get more than it can by settling its problems at the bargaining table. Scientific management has been able to solve practically every problem but labor relations. Nevertheless the scientific approach to this problem promises hope. Such an approach to labor relations involves an area in which little work as yet has been done. The logics of sentiments control human relations more than the logics of efficiency.[2] Although scientific methodology can be applied to this area of management also, the technique is not so simple, and a longer time is required to see the results than is necessary in material things.

Definitions The study of the managerial and administrative phases of business is so new that as yet there has not emerged a standardized terminology that is generally accepted. This is particularly true of the terms *administration* and *management*. In governmental agencies administration is frequently considered the more all-inclusive of the terms. In business circles the reverse is often the case. This is especially true when referring to the persons that are responsible for the function, for instance, the *management* would refer to the top executives charged with policy formation and the direction of the enterprise. In governmental circles most generally it would be the *administration*. With a full recognition that our British cousins and some American businessmen (particularly those who have held governmental positions) use *administration* to refer to the active

[2] See F. J. Roethlisberger and William J. Dickson, *Management and the Worker*, Harvard University Press, Cambridge, 1940, Chapter XXIV, for an excellent discussion of this subject. The Survey Research Center of the University of Michigan is doing some excellent work in this area of human relations.

carrying out of policies laid down by management, we prefer the definitions as given here The student should be careful in his reading in all managerial literature not to be confused by this dual use of the terms He must also keep in mind that in one sense, management refers to the executive *personnel* of an enterprise and is frequently used with special reference to the major executives largely responsible for policy formation and the determination of the major objectives Such phrases as "top management" and "lower levels of management," when referring to the individuals who discharge the respective administrative or executive functions, are quite generally used regardless of the special interpretation given the words administration and management when used in their functional sense This practice is satisfactory when the context clearly shows that the reference is to executive personnel

We prefer to think of *administration as that function of an enterprise which concerns itself with the over-all determination of policies and major*

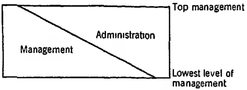


FIG 1 1 Chart illustrating the division of managerial and administrative functions between top management and the lowest level of management

objectives Administration sets forth the general purpose of the enterprise, establishes its major policies, formulates the general plan of procedures, inaugurates the broad program, and approves the specific major projects that fall within the general program It should not be inferred that two sets of personnel are required to discharge the administrative and the managerial functions There is usually a distinct overlapping of individuals in these respective spheres In a large institution the president may devote a great part of his time to the broader administrative responsibilities, on the other hand, he is most certainly required to participate, to at least a limited extent, in executing these policies The farther down the organization one goes, the greater is the shifting from responsibility of policy determining to execution (see Fig 1 1)

Management is that function of an enterprise which concerns itself with the direction and control of the various activities to attain the business objectives Management is essentially an executive function, it deals particularly with the active direction of the human effort Administration determines the broad objectives and establishes the major program Ad-

ministration is largely determinative, whereas management is essentially executive. The major responsibilities of the executives below the "top management" are largely managerial. It is true that many of the minor executives in a limited sphere determine policies within the groundwork established for the organization as a whole.[3]

Business objectives. Owners of capital and the hired managers of business enterprises combine their efforts to run an endeavor that will produce a good or service so efficiently that the manager will be adequately rewarded and the owners receive an acceptable profit.

Profits through service is both a socially and economically desirable goal of business. Owners of capital have a right to expect a reasonable return on their capital when they place it in the hands of others for use, as they do in our corporate structures, or when they personally supervise it in a single proprietorship.[4] The enterprise that does not earn a fair return on its capital faces ultimate disaster. (It is not necessary to go into a detailed discussion of what is a fair return. The Supreme Court has placed it in the neighborhood of 6 per cent in the case of certain utilities.) When an enterprise earns less than what investors deem a fair return, it cannot secure needed capital for expansion. Other industries in a more favorable situation will be able to make improvements and expand, thus putting the first one at a still greater disadvantage. In the long run the business that does not earn sufficient return on its invested capital to command additional funds when needed will be forced to close its doors, thus depriving its employees of a source of employment.

Large-scale business has passed almost entirely into the hands of hired managers and these managers are becoming more and more men with training equaling that of professional men. One of the distinguishing characteristics of professional men is a highly developed code of ethics that includes social objectives. A large number of trade associations and other groups of business men have adopted codes of business ethics. It is fully recognized that these codes are not always adhered to, but neither are other professional codes, social codes, or even religious codes. The business man who makes a financial success of his enterprise while operating within

[3] See E. H. Anderson and G. T. Schwenning, *The Science of Production Organization*, John Wiley & Sons, New York, 1938, pp. 9–28, for a detailed discussion of the various usages of *administration* and *management* by different authors.

[4] The economist thinks of profit as the residual income after having paid rent for land, interest on capital used, both owned and borrowed, and wages to labor and the executives. Profits, if any, are available to the owners of the enterprise, the common stockholders of a corporation, the members of a partnership, or to the individual if he is the sole proprietor. In an accounting sense, profits represent the excess of income over all expense. Dividends on stock are not considered an expense.

the generally accepted codes of business ethics or even on a higher level, if possible, makes a real contribution to the community welfare Long-run prosperity in business brings success not only to the owners of the business in the sense of proprietary risk-bearers but also to all persons who supply funds and materials, major and minor executives, workers, auxiliary enterprises, and the operating community In a very realistic sense a successful business becomes a cooperative enterprise carried on within the limitations of our capitalistic system of private responsibility and initiative Profit motives are entirely compatible with social objectives and have proven the strongest incentives to attaining these objectives

The field of business In this book *industrial management* is used in its broadest sense to include all kinds of businesses Different kinds of business require different backgrounds and skills but the basic managerial requirements are essentially the same Managerial and administrative responsibilities and duties call for the utilization of different types of genius, which are not always found in the same man To establish policies and to plan for an effective organization require mainly creative ability, although this must be coupled with some power to visualize methods of executing the plans that are devised To operate a plant in accordance with the policies which have been laid down requires mainly executive ability The manager who has this gift, together with the ability to create new policies, possesses the characteristics needed by top management

Any kind of business in its initial establishment and later operation requires three steps

1 The establishment of major policies
2 The planning for and establishment of an organization to carry out these policies
3 The operation of the enterprise through this organization As business conditions change, fundamental changes are needed in each of these fields If a plant does not make changes from time to time as needed, it sometimes becomes necessary to engage in extensive reorganization, which, because of its spectacular aspects, may come to be looked upon wrongly as the main field of the science of management The best advertised managerial effort has been reorganization, because it is spectacular

The three broad areas in business are *production, finance,* and *selling* The other areas are subsidiary to these three basic fields The banker requires a high degree of managerial effort in operating his enterprise, and he is vitally interested in the type of management in the business to which he makes loans Large banks have managerial specialists to appraise the effectiveness of prospective borrowers The balance sheet alone does not tell the whole story Any serious attempt to study industrial management requires an analysis of those administrative and managerial policies that

have been most effective, to understand the physical phases of production, and to discover the proper balance among the managerial, physical, and employee relationships In order to fulfill this aim, three steps are necessary (1) to determine the policies and principles of effective administration and management, (2) to see how they have been applied successfully, and, most important of all, (3) to develop a scientific state of mind toward business problems

2 THE MANAGERIAL MOVEMENT

The early stages The phenomenal growth of business during the closing years of the nineteenth century and the first quarter of the twentieth century provided a fertile field for the growth of the management movement. This phenomenal growth forced managers to turn to the researches in management for help. This period produced John D. Rockefeller, Sr., the moving spirit in the oil industry, James J. Hill, the railroad builder, John Patterson, who provided the cash registers for the new industrial era, Henry Ford and the Dodge brothers, Horace and John, founders of automobile industries bearing their names, Harvey Firestone, in the rubber industry, Marshall Field and John Wanamaker, who revolutionized certain aspects of retailing, and Thomas Edison and the Wright brothers, great inventors who laid foundations on which others have built huge industries. Their beginnings were humble, such as the bicycle shop of the Wrights and the small machine shop of the Dodges, yet most of them lived to see their works prosper to an extent little dreamed of, even by them, in their early efforts. They grew with their enterprises. They possessed an intimate, detailed knowledge of each phase of their undertakings. As they grew, these men carried enormous personal loads and responsibilities. They developed the faculty for ease and speed of decision. This capacity was fostered by complete mastery of technical details and the assumption of responsibility early in life.

Frederick W. Taylor While the captains of industry were building their enterprises, the natural scientists, engineers, and students of management were laying the foundations on which the captains of industry were destined to build an industrial nation that continues to be the marvel of the entire world. Between 1880 and 1890 Frederick W. Taylor laid the foundation for modern scientific industrial management. Taylor was himself strongly influenced when still comparatively young by knowledge of the work of Henry R. Towne, then president of the Yale and Towne Manufacturing Company, who began the application of new management methods as early as 1870 in the plant of that company. Although Towne may have been the pioneer, Taylor was the great leader of the movement. At the time of Taylor's death, Towne himself referred to him as "one of the world's

discoverers and creative leaders" and as the "creator of a new science " Another personality that greatly influenced the early work and entire philosophy of Mr Taylor was his chief, William Sellers, one of America's greatest engineers, who possessed a keen understanding of his young assistant's enthusiasm and a profound respect for research Sellers encouraged him in his efforts and made available to him equipment suitable for the researches The keen analytical ability of Carl Barth, one of Taylor's assistants at the Bethlehem Steel Company, aided him greatly in the refinement of techniques and in the use of mathematical tables and processes Taylor occupies the same position in regard to the science of management that Darwin does to the modern approach to the pure sciences

Taylor's early work Taylor was made foreman of the machine shop in the Midvale Steel Company in Philadelphia in 1882 This was the beginning of a long and successful career as a manager, management consultant, and industrial scientist As an earlier workman Taylor had been impressed by the failure of many of his fellow-workers to produce more than a third of a good day's work The men did not want management to know how much work they could do for fear that the rates would be cut When Taylor became foreman, he tried to work out some system of management whereby the interests of management and the men might be made the same Taylor knew that management lacked knowledge of what a day's work really should be How could a man be held accountable for his full duty when the management had no idea of his capacity? Taylor found that management did not really manage and that its attitude toward its responsibilities in this direction had to be changed before the workman could be expected to change his attitude toward his work Taylor felt that the management was asking the worker to do its work as well as his own From his work at Midvale Taylor developed his "duties of management," which may be summarized as follows [1]

1 The development of a science for each element of a man's work, thereby replacing the old rule of-thumb method

2 The selection of the best worker for each particular task and then training, teaching, and developing the workman, in place of the old practice of allowing the worker to select his own task and train himself as best he could

3 The development of hearty cooperation between the management and the men in carrying on the activities in accordance with the principles of the developed science

4 The division of the work in almost equal shares between the management and the workers, each department taking over the work for which it is better fitted, instead of the former condition in which most of the work and the greater part of the responsibility were thrown on the men

[1] F W Taylor, *Principles of Scientific Management*, Harper, New York, 1919, p 36, reprinted in *Scientific Management*, 1947

While at Midvale Taylor carried on early experiments in the development of high-speed steel His discovery of high-speed steel, in which he was associated with Maunsel White, ranks as an achievement equal to the founding of the modern management movement The work which he did on high-speed steels was an outgrowth of his attempts to find the right way to do jobs When Taylor left Midvale in 1890, it was largely due to factional differences within the organization This situation naturally led to the undoing of much that he had accomplished Nevertheless, even today many of the practices in the machine shops of this plant can be traced back to the time when Taylor was first working there with management methods For several years Taylor did not have an opportunity to continue upon a large scale the work that he had begun at Midvale Although engaged in a number of undertakings in which he aimed to improve managerial methods—several being largely concerned with improvements in cost accounting—there was no one great work carried on in one plant Beginning in 1898, Taylor worked at the Bethlehem Steel Company for 3 years With the aid of a large and competent force of assistants he reorganized the management and methods of two of the larger machine shops and the foundry and at the same time completed the development of his metal-cutting experiments It was at Bethlehem that the interesting studies in pig-iron handling and shoveling were made, which since have become classic in the field of management One of the most important of the wage-payment systems was also developed during this time After Taylor had been at the Bethlehem Steel Company for about 3 years, there was a change in the directorate and executive management of the company The group which came in was unfamiliar with the methods pursued by Taylor and his staff and apparently antagonistic to them Taylor and his associates left This withdrawal was followed by changes in method by the new management, and since this development so closely followed the upheaval at Midvale, it cast a shadow on Taylor's work which took some years to live down This accounts for the slow development of his ideas during the immediately succeeding years Among the more important plants in which Taylor or his direct associates worked in this period were the Tabor Manufacturing Company and the Link-Belt Company of Philadelphia and the United States Arsenal at Watertown, Massachusetts

The pig-iron experiment at Bethlehem Taylor described his experiments as follows

This was done by timing with a stop watch a first class man while he was working fast The best way to do this, in fact almost the only way in which the timing can be done with certainty, is to divide the man's work into its elements and time each element separately For example, in the case of a man loading pig iron onto a car, the elements should be (a) picking up the pig from the ground or pile (time

in hundredths of a minute), (b) walking with it on a level (time per foot walked), (c) walking with it up an incline to car (time per foot walked), (d) throwing the pig down (time in hundredths of a minute), or laying it on a pile (time in hundredths of a minute), (e) walking back empty to get a load (time per foot walked)

In case of important elements which were to enter into a number of rates, a large number of observations were taken when practicable on different first-class men, and at different times, and they were averaged

The most difficult elements to time and decide upon in this, as in most cases, are the percentage of the day required for rest, and the time to allow for accidental or unavoidable delays

In the case of the yard labor at Bethlehem, each class of work was studied as above, each element being timed separately, and, in addition, a record was kept in many cases of the total amount of work done by the man in a day The record of the gross work of the man (who is being timed) is, in most cases, not necessary after the observer is skilled in his work As the Bethlehem time observer was new to this work, the gross time was useful in checking his detailed observations and so gradually educating him and giving him confidence in the new methods

The writer had so many other duties that his personal help was confined to teaching the proper methods and approving the details of the various changes which were in all cases outlined in written reports before being carried out

As soon as a careful study had been made of the time elements entering into one class of work, a single first class workman was picked out and started on ordinary piece work on his job His tasks required him to do between *three and one-half* and *four times* as much work in a day as had been done in the past on an average

Between twelve and thirteen tons of pig-iron per man had been carried from a pile on the ground, up an inclined plank, and loaded on to a gondola car by the average pig-iron handler while working by the day The men in doing this work had worked in gangs of from five to twenty men

The man selected from one of these gangs to make the first start under the writers' system was called upon to load on piece work from forty-five to forty eight tons (2,240 lbs each) every day

He regarded this task as an entirely fair one, and earned on an average from the start $1 85 per day, which was 60 per cent more than he had been paid by the day rate This man happened to be considerably lighter than the average good workman at this class of work He weighed about 130 pounds He proved, however, to be especially well suited to this job, and was kept at it steadily throughout the time that the writer was in Bethlehem, and some years later was still at the same work

Being the first piece work started in the works, it excited considerable opposition both on the part of the workmen and of several of the leading men in the town, their opposition being based mainly on the old fallacy that if piece work proved successful a great many men would be thrown out of work, and that thereby not only the workmen but the whole town would suffer

One after another of the new men who were started singly on this job were either persuaded or intimidated into giving it up In many cases they were given other work by those interested in preventing piece work, at wages higher than the ruling rates In the meantime, however, the first man who started on the work earned steadily $1 85 per day, and this object lesson gradually wore out the concerted opposition, which ceased rather suddenly after about two months From this time on there was no difficulty in getting plenty of good men who were anxious to

start on piece work, and the difficulty lay in making with sufficient rapidity the ac curate time study of the elementary operations or "unit times" which forms the foundation of this kind of piece work

Throughout the introduction of piece work when after a thorough time study, a new section of work was started, one man only was put on each new job, and not more than one man was allowed to work at it until he had demonstrated that the task set was a fair one by earning an average of $1 85 per day After a few sections of the work had been started in this way, the complaint on the part of the better workmen was that they were not allowed to go on to piece work fast enough

It required about two years to transfer practically all of the yard labor from day to piece work And the larger part of the transfer was made during the last six months of this time

As stated above, the greater part of the time was taken up in studying "unit times," and this time study was greatly delayed by having successively the two leading men who had been trained to the work leave because they were offered much larger salaries elsewhere The study of "unit times" for the yard labor took practically the time of two trained men for two years Throughout this time the day and piece workers were under entirely separate and distinct management The original foremen continued to manage the day work, and day and piece workers were never allowed to work toegther Gradually the day work gang was diminished and the piece workers were increased as one section of work after another was transformed from the former to the latter [2]

Taylor as a writer and apostle of the scientific methodology Taylor finally turned from management consulting to recording his experiences so that many could profit from his researches and experiences Taylor was disappointed at the reception of his first paper, *A Piece Rate System,* read before the Society of Mechanical Engineers in 1895 He had used a popular title as a medium of getting fundamental managerial principles before his associates They remembered the vehicle but forgot its fundamental concepts He tried to correct this situation in his later paper, *Shop Management,* read before the same society in 1903 A few of his audience grasped his over-all concept of scientific management, but most of them focused their attention on details, entirely overlooking his basic plea In December, 1906, Taylor presented as his presidential address to the same society his *The Art of Cutting Metals* From that time until his death on March 21, 1915, he devoted himself almost completely to the task of spreading the gospel of scientific management Although there had been a constant improvement in management methods and many men were already making management service a life work, in 1910 scientific management had not captured the fancy of any large portion of the industrial world

Taylor's position in the management field is that of the first thorough explorer His researches, because of his personal ability, carried him

[2] F W Taylor, *Shop Management,* Harper, pp 48–52, as reprinted in *Scientific Management,* Harper, New York, 1947, pp 48–52

further than might have been expected Unfortunately, he was not a salesman, as far as his own work was concerned Those close to him were always able to see the careful thought and study behind his conclusions, but others did not have this advantage

After Taylor gave up the active practice of management installation, a number of his direct followers quickly appeared to carry on his active work These men became known as the Taylor School in management work, because their close association with the leader of the movement caused them to be guided in their work largely by Taylor's own methods At the same time the influence of Taylor was guiding other men in distant parts of the United States and even in other countries along paths which led to the same goal In the hope of finding methods that would avoid the problems that occasionally arose in connection with some of Taylor's detail methods, these men developed other procedures which frequently seemed to differ from those of Taylor Although the devices differed, the principles, if the work was sound, were Taylor's In fact, even when opposition to Taylor's work still existed, manufacturing executives who thought themselves opposed to Taylor were, in fact, following frequently the very lines of thought that were primarily his This situation was due to the wide diffusion of Taylor's principles through his disciples and also to the fact that his principles were basically sound for the era into which manufacturing was entering

Taylor's wage theory The interest of engineering societies during the more formative years of Taylor's industrial life was centered on segments of managerial activities rather than in "scientific management" as an entity Taylor evolved a system which was a part of his broader program of managerial controls His first premise was that no wage plan was equitable either to men or to management unless it was based upon accurate knowledge He contended that in most instances this knowledge was lacking but that it was determinable, as illustrated by the description of timing pig-iron handling His major emphasis was upon carefully establishing tasks and making their attainment possible This placed a heavy responsibility upon the executive group, for workers would not long remain silent when they received low pay because of the shortcomings of their bosses Taylor's program provided a high reward as an incentive for the worker to accomplish the established task On the assumption that accurate standard tasks have been established, the essence of Taylor's differential wage is as follows

1 The maintenance of such conditions that the daily task can be accomplished by the worker

2 High pay for tasks successfully completed

3 Low pay for failure to attain the required task

Taylor's attitude toward unions Contrary to an erroneous opinion, Taylor was not opposed to organized labor as such In his opinion scientific management removed the need for organized labor, but he stated, "There is no reason on earth why there should not be collective bargaining, under scientific management just as under the older type, if the men want it "[3] Under many situations prevailing in industry Taylor specifically sanctioned combinations of workmen as a matter of necessity to protect their interests "When employers herd their men together in classes, pay all of each class the same wages, and offer none of them any inducements to work harder to do better than the average," he said, "the only remedy for the men lies in combination, and frequently the only possible answer to encroachments on the part of their employers is a strike "[4] He severely criticized organized labor's restriction of output, the use of force or intimidation, and the oppression of nonunion workmen On the other hand, he commended wise union leadership that promotes cooperation, naming particularly the Brotherhood of Locomotive Engineers as an example[5] Taylor believed that scientific management removed the necessity for labor organizations but that there was no logical reason why men should not affiliate with unions of their own choice under scientific management[6]

The management movement goes west Sections of the country which were less conservative in management method adopted the new ideas more readily and in larger proportions than did eastern sections New businesses which were developing, such as the automobile and allied industries, had a made-to-measure opportunity to develop management method along with manufacturing technique These industries were located mainly in the Middle West This section grasped the opportunity of increasing effectiveness of operation that was offered by management method and gradually developed, in many scattered localities, procedures of operation which, although built on the same firm foundations as those that served the early leaders of the management movement, were constructed along newer and bolder lines The best-known illustrations of this work are the automobile industries, whose demonstration of the economies incident to standardized operation, continuous assembly, and newer wage-payment concepts has profoundly influenced the whole of American industry

[3] *Hearings before Special Committee of the House of Representatives to Investigate the Taylor and Other Systems of Shop Management* Washington, 1912, p 1444

[4] Frederick W Taylor, *Shop Management*, Harper, New York, 1919, p 186, as reprinted in *Scientific Management*, 1947

[5] Frederick W Taylor, *Shop Management*, Harper, New York, 1919, p 188, as reprinted in *Scientific Management*, 1947

[6] See Edward Eyre Hunt, *Scientific Management Since Taylor*, McGraw-Hill, New York, 1924, p 52

The management consultant Specialists in managerial consulting have acquired professional status They have an association whose members follow a rigid code of ethics Relatively few small or medium-sized industrial enterprises are organized in such a way as to have a broadly trained group of men whose sole duty is to collect facts, appraise the overall situation both within and without the enterprise, and give impartial recommendations Many executives, even the group largely responsible for policy determination, are tied down with managerial responsibilities Few of them have the time, the temperament, or the capacity for objectivity necessary to appraise the results of their own handiwork In enterprises both large and small pressing problems arise from time to time that require very special treatment In the larger organization it is possible to set up a special department to do the required work, in some of them such a department exists Seldom indeed are men with adequate training found within a given organization when it is desired to establish such a department, the personnel is usually recruited mainly from the outside Where time is an important element, it is nearly always preferable to secure the services of an established professional consulting firm rather than to try to establish such a department within the firm In those firms already having distinct departments established for making surveys and formulating policies, it is seldom indeed that these departments have the wide contacts and thorough knowledge of prevailing practices in similar situations that the outside professional organization possesses Frequently the regular executive lacks the time to make intensive studies and analyses because of the interruptions of routine affairs Moreover, the professional consultant is practically free from the suspicion of prejudice or favoritism frequently encountered when recommendations are presented by interested parties He is in a position to state plainly from without certain truths that could not safely be expressed by persons within the organization The qualified consultant has acquired techniques of working quietly and effectively within an organization without disturbing the routine functioning of the enterprise

In the broadest sense management has become the profession of the plant executive, not merely the profession of the few who specialize in it Those who specialize in management fit into the scheme as special counselors, cooperators to the managing executives of industry The management engineer fills a very real niche in the halls of industry He is a product of the age of scientific management and the age of specialization in industry He specializes in management and administration and sells his services, either along general or special lines, to the executive in charge of the enterprise He brings to one plant the knowledge of many He helps to rehabilitate run-down concerns by bringing in the refreshing stimulus of an

outside point of view, and he also renders a special service to the prosperous, well-managed enterprise

As a recent development, the various phases of industrial consulting have become rather specialized For instance, one type of industrial consultant advises only concerning the construction of a new building or the remodeling of an old one, specializing in such matters as the type of building construction, fire hazard, or the routing of the product through the factory Even more recently, the consultant who deals only with personnel administration has found a place in the industrial scene The labor-relations counselor is a specialist in one phase of personnel administration, namely union-management relations The management consultant rendered an invaluable service in the new plants built to meet the requirements of the World War II and the Korean War effort Every phase of management, building the plant, making the plant layout, training the executives and workers, constructing the organization structure needed for operations, and guiding the enterprise through the early days of operation, was aided by the management consultant Managerial knowledge was thus multiplied many times through the aid of the professional management consultant Both the Army and the Navy used the management consultant to streamline operating procedures in Washington as well as in the field A national authority applied the principles of motion economy to certain phases of operations in the Pacific theater Another specialist studied the submarine and improved the arrangement of the control mechanisms

The Air Forces and the Army have their own groups of management specialists who are doing a very high grade of work, particularly in the arsenals, supply depots, and maintenance centers

The management specialists within the company General Electric has a vice-president who specializes in the organization and management function as a staff aid to the line operating people In recent years some companies have created a new department known as the *organization department* which specializes in establishing organization structure, maintaining balance in the organization, developing an organization manual, reviewing the performance of the respective departments, and maintaining control through the budget Many of these activities belong in the personnel department and the others in the comptroller's division There may be an advantage in setting up the organization department as a separate unit when the personnel director is not capable enough to handle this function It is better organization, however, to secure a personnel director of vice-presidential caliber who can direct the activities of the organization department as a section in the personnel division rather than to have another department reporting to the president or other top executive These groups in industry have an important part in the progress that the scien-

tific management movement is making, for they have the advantage of daily contact with the management problems with which they deal The consultant is of service even to them, for he brings the experience of many organizations to help in the solution of the problems that confront them The organization department is also an outgrowth of activities often performed by the methods department and the industrial engineering department The industrial engineer studies methods, procedures, and processes to increase their efficiency Frequently, the motion- and time-study department is under the direction of the industrial engineer The methods department takes the blueprints from the product engineer, specifies the routing of the product through production, and designs tools, jigs, and fixtures for use in actual operations At times the industrial engineer makes studies of organization structure as well as procedure This is not a common practice, however, since relatively few engineers are specialists in organization

Is the management movement leading to professionalization? There is no doubt that many phases of the management movement lead to professionalization The high-calibered management consultant is a professional man Nevertheless, the great part of the managerial work will continue to be carried on by persons who are technicians rather than professional men They learn by doing and give little thought to causal relationships With an increase in the number of professional managers in business both as operating men and staff consultants, the level of performance of the persons who perform their managerial functions as an art rather than a science will increase The future for scientific management is bright Staff departments which once seemed inseparably attached to any form of scientific management have been eliminated by some companies in times of financial stress, yet, the scientific management method has been used by these companies in attacking their problems The true scientific approach to the question is the study of the service that such a department may render or has rendered, as compared to the cost of its operation This same comparison, of course, must be expanded to include alternative departments, if any, other than the one under consideration that might do the desired work

In the early days organized labor opposed the scientific management movement [7] Even today certain segments of organized labor will have no part in the scientific determination of labor standards On the other hand, organized labor has appropriated many of the techniques and philosophies of scientific management The International Ladies Garment Workers' Union maintains an industrial engineering department that repre-

[7] See *Hearings before Special Committee of the House of Representatives to Investigate the Taylor and Other Systems of Shop Management,* 1912

sents the union in establishing standards "We urge upon management the elimination of waste in production in order that selling prices may be lower and wages higher " This statement was contained in a resolution adopted at the convention of the American Federation of Labor in 1925 In the words of the late President William Green of the American Federation of Labor, labor realizes " that its future welfare and best interests are interdependent with industrial progress and business prosperity, and we are placing a distinct emphasis on proposals that will lead to opportunities for co-operation " A statement of policy by the Steel Workers' Organizing Committee, C I O , shows the attitude of cooperation on the part of a section of labor toward certain aspects of scientific management

1 The Union agrees to cooperate with the management in order to reduce costs, enlarge sales, improve quality, and in general advance the interests of the industry

2 The management agrees to share equitably with the union any benefits so obtained in the form of increased employment, better working conditions increased rates or decreased hours

3 Nobody is to lose his job as a result of any improvement that is installed If ways are discovered to do more work with less labor, they are to be adopted naturally and then only with the consent of the union They must be installed in such a way that no discharges are necessary—for instance at a time when sales and output are increasing

4 The research must be truly joint in every respect All facts and plans are to be revealed to the union committee and its understanding and consent must be obtained at every step [8]

A number of factors are combining to insure steady progress for the management movement Among them are the growth of societies [9] whose membership consists largely of plant executives and whose interests lie entirely with management problems, the increasing output of literature, both periodicals and books, on scientific-management subjects, and the attention being devoted by the next generation of factory managers, now in educational institutions, to management as a study

Just as the growth of scientific education in colleges during the last 50 years has aided in revolutionizing American industry, so the expansion of managerial education is likely to aid the management movement in further revolutionizing it In 1915 there were not five courses in management given in American universities Today practically every business and engineering school in the United States offers management courses

[8] The Steel Workers Organizing Committee Production Problems,' *Publication No 2*, 1938

[9] Such societies as the American Management Association, the Society for the Advancement of Management the Industrial Management Society and the Management Section of the American Society of Mechanical Engineers provide professional support to scientific management and publish the findings of their members

Although this extremely rapid growth of management instruction has been in response to the demand from industry, in many cases it has led the demand and has, through its graduates, called the attention of industry to the strides that have been made in management in other sections of the United States Some schools cooperate with business so that the student goes to school 3 months and works for 3 months In this manner the student is enabled to combine practical experience with a study of basic principles

Scientific management is no longer confined to the factory Its principles are being applied to retailing, banking, transportation, hospitals, and practically every activity where large numbers of people are employed

3 BASIC MANAGERIAL DECISIONS

Decision making In scientific management the steps in decision making are (1) get the facts, (2) analyze the facts, (3) consider the objective in the light of the available facts, and (4) decide Unfortunately, action frequently has to be taken without all the facts If immediate action has to be taken, time is not available for collecting all the facts In this case past experience serves as a valuable guide When decisions involving the future are required, facts simply are not available but an analysis of the total situation gives a guide No amount of study and analysis of business conditions in 1949 would have likely predicted the Korean War Many of the long-run business decisions can be supported by scientific forecasting but there still remains a measure of enlightened insight in terms of past experience In view of the uncertainties of predicting the future, it is wise to be in a flexible situation most of the time Business decisions need to be re-evaluated from time to time

Size There is no single answer as to how large a company should grow Its competitive strength or the desires of its management may be the determining factor An interesting announcement of policy concerning the size of a business was made by the Royal Metal Manufacturing Company of Chicago President Irving Solomon of this company has said, "Sales of Royal Furniture are purposely limited to $1,500,000 annually Reasons This permits the president personally to watch quality, to know each worker by name, salesmen are not harassed by constantly rising quotas, not high-pressuring unwilling buyers If dealers cannot supply, buy from Royal's worthy competitors "[1] In another national advertisement the Royal Metal Manufacturing Company actually named six of its competitors, from whom it recommended that customers buy if the stated policy of the company did not make it possible to satisfy all of them

It is a dangerous policy for a company to give all its product to one buyer Should this buyer decide to purchase elsewhere the company would find itself in evil days

Once a company becomes successful, there is always the urge to expand the manufacturing facilities in good times to meet possible sales Fine

[1] Advertisement in *Time*, November 10, 1936

judgment is required to know how far facilities can be safely increased and when the decision should be made to sell only as much as the present plant can produce or as can be safely contracted out for manufacture A closely knit organization which has been successful in building a business because of the close contacts and understanding among its respective members may become overstrained and weakened by the task of operating a much larger business in which the personal touch is not so important as carefully laid and integrated organization plans There is a particularly big jump between a business sufficiently small for one man to oversee all the details and one so large that a single individual is unable to keep in touch with all its details

General Motors Corporation operated 115 plants during World War II By following its philosophy of decentralized responsibility for operations with advice and coordination from the home office, this organization could have operated 150 plants if it had had sufficient trained executive personnel or had had time in which to train these executives Multiple-plant operations require a different organization structure for maximum efficiency Organization structure and trained personnel to assume executive positions are the controlling factors in the size to which any enterprise may grow This statement, of course, is based upon the assumptions that the product is desired by the public in sufficient quantities to sustain the expansion and that the productive efficiency is such as to enable the company to meet competition The growth of a business does not imply that the home plant may continue to expand indefinitely because freight costs of the finished product may dictate the construction of additional plants nearer the markets rather than the extension of the market of a single plant The best rule that can be suggested is that a size be maintained that will always leave the company liquid from the standpoint of working capital, that will enable it to keep up with product developments in its field, and that will keep it large enough to influence the trend of products and style in its field If the organization is not large enough to meet these requirements, it will be in the dangerous position of having to follow the lead of its important competitors and may run the danger of seeing an investment in machinery and equipment wiped out almost overnight by sudden trends away from its product

Buy or make? As conditions within or without the enterprise change, the decision should be reappraised in the light of the new situation Although the profit aspects of a completely integrated business are recognized, there are many disadvantages incident to making materials or parts which can be bought as cheaply, or almost as cheaply, as they can be manufactured Some of the factors involved are as follows

Why Parts Can Be Bought More Cheaply

1 Occasionally advantage can be taken of depression conditions to buy at less than the full cost of manufacture including interest on investment and depreciation This is particularly true of articles in which the field is highly competitive

2 The processes incident to the manufacture of the part are often foreign to the remainder of the business

3 There may be greater chance of obsolescence of the machinery needed to manufacture a particular part than in the remainder of the process In such cases it is advantageous to allow another manufacturer to own such machinery

4 The requirements of the business for the part or material may be only a small fraction of the total requirements for the material from other dissimilar businesses Under such conditions buying will afford the independent manufacturer the advantage of others' large scale purchases for his requirements

5 At any given time the extent of capital available to a given business may make it more profitable for the business to utilize its capital in sales and other business promotional or research activities, rather than to tie it up in machinery and materials for the manufacture of portions of the product which can be purchased

Why Parts Should Be Made

1 During times of prosperity particularly when a certain product has taken the fancy of the buying public it is sometimes difficult to secure prompt deliveries on rapidly rising requirements from usual sources of supply, and at such times new sources are difficult to develop with sufficient rapidity

2 Processes into which hidden quality is put and which have much to do with the acceptance of a particular article can be more satisfactorily made by the company responsible for the quality guarantee

3 On style merchandise parts or materials which give clues to the appearance of articles to be made for a particular season sometimes may advantageously be kept from competitors as long as possible

4 Particularly for large companies, the policy of manufacturing a portion of the most important parts provides a continuing yardstick concerning the proper cost of such parts and also a means of preventing suppliers from arbitrarily increasing price in times of greatest need - Similar effects have been secured repeatedly by threatening to undertake the manufacture of some purchased part, often long time contracts at favorable prices have been secured by this means

The price field The decision as to the price range of a product will not only influence their manufacturing methods, machines, and personnel but also their basic methods of distribution Low-grade, volume products generally must be distributed on a wider more inclusive scale than medium- or high-grade products Profits per unit will be much smaller, but in so-called volume products the potential sales outlets are so much larger that their attractiveness lies in the greater potential profits These potential

- This also has the effect of letting the manufacturer s department operate at full capacity at practically all times, leaving the occasional excess requirements to the company from which parts are purchased

profits, however, bring in their wake at least three added problems (1) more intense competition, (2) price pressure from distributors and dealers, and (3) the costs of added plant and equipment if the article is favorably received This requirement becomes increasingly burdensome if the demand for the article is transitory It is difficult for management to resist the siren call of the distributor or dealer who wants low-priced merchandise Frequently this merchandise is asked for "as a leader," with the assurance that there is no intention to push it, but only to use it as a means of attracting customers With assurance of this kind from distributors and dealers many manufacturers have been led to produce merchandise selling considerably under anything which they have previously offered The manufacturer then discovered that the market had come to be educated to the new low prices as the proper amount to pay for the article and that a large proportion, if not a majority, of the sales were made in the new low-price brackets, with accompanying low profit margins

Selecting sales outlets The price range of a product may dictate the type of sales outlet, conversely, the type of sales outlet available may be controlling in deciding the price range of the product to be manufactured For example, a manufacturer of gas stoves and refrigerators has a choice of several methods of distribution or of combinations of them, as follows

1 Through public-utility companies
2 Through a distributor organization, with distributors utilizing specialty stores and hardware stores as outlets
3 Through department stores, which ordinarily will not buy through distributors but wish to buy direct from the factory
4 Through large stores in some cities, which ordinarily buy as do the department stores, but which may also act as distributors in their section

In some cases it does not prove practical to sell through several types of merchandising agencies, even in widely separate districts, especially through public utilities and department stores The type of merchandise that they demand and the type of sales-promotion methods which they use are usually different The department store has a series of sales scattered throughout the year to attract customers to the store For these sales the store must secure from the manufacturer "specials," which will be only slightly different in design and grade from regular merchandise, but which must offer values that prove to be outstanding to the customer Only a few department stores can successfully, over a period of years, promote the sale of the more expensive, most completely equipped gas stoves Such items have been distributed most successfully through the public-utility companies, the specialty stores, or distributors The decision to distribute directly or through distributors is determined for any product by a number of factors other than quality Some products can be most successfully

distributed through distributors Other products may be sold to retailers, whereas still others may be sold directly to the consumer The custom in the trade will exert an influence, a strong organization, however, may establish its own custom There is some difference between marketing a producer's heavy good and a widely used consumer's product The former type may require a highly specialized technical knowledge not readily available among the usual distributors Almost any product, however, has more than one channel of distribution, largely depending upon the managerial decisions of the particular enterprise Such items as availability of funds, availability of desirable outlets, and credit policies may be immediately controlling

Diversification of product The decision to diversify the products is different from diverse models of the same product It is a decision concerning the number of fields of industry in which the company should engage Some companies with large financial resources have tended to invest in manufacturing products in related fields, particularly in articles which can be distributed through the same outlets Other companies, however, have spread their activities over widely divergent fields which would tend to assure them profits if their original field was slack and would give them the opportunity to utilize the managerial brains and experience which they had developed to produce additional profits for their stockholders The development of General Motors from a corporation having only automobile manufacture as its interest to a corporation having large diversified interests is an illustration This corporation, in addition to its automotive divisions, covering the field from the lowest- to the highest-priced car, and its ignition, lamp, starter, foundry, gear, axle, and other plants, has secured a commanding position in the manufacture of electric refrigerators, electric motors (for both domestic and industrial use), diesel engines, air-conditioning units, and railroad equipment It is by no means a settled question that this type of expansion to secure diversity is entirely advantageous In many instances, after a certain size has been reached, economies derived from further expansion are open to serious question Strong individual producers are still succeeding in practically all the fields that have been entered by these larger corporations

After World Wars I and II many companies, finding themselves with excessive productive capacity, took on new products in addition to the ones that they manufactured before the war Some of these companies continued to succeed but others fell by the wayside It is one thing to succeed in producing an item for which there is a tremendous latent demand arising from war economy and quite another thing to meet keen competition during normal times Should a company with a moderately successful experience over a period of years in the manufacture of polyphase electric

motors for industrial use invest a portion of its accumulated surplus to endeavor to wrest a portion of the attractive household electric-refrigerating motor business from its more powerful competitors? The company may have the technical and managerial skill to produce this new line of motors, even though they are single-phase and all its experience has been with polyphase motors Before venturing into the new field management should seek answers to the following questions

1 If our product is just as good or a little better, will we not have to sell it cheaper than our larger competitors in order to secure a portion of the business? And if we do that, will not our competitors, with their greater financial resources, drive down the price still further, so that it will be unprofitable for us?

2 Are we certain that our engineering ability will give us products which will stand up in quantity manufacture so that hidden defects in our first year s production will not cause large quantities of these high-production motors to be returned to us under our guarantee? If this happens, have we the financial resources to withstand one such setback?

3 Would not the amount of managerial and sales effort necessary to secure a portion of this new business be better expended in improving and enlarging our field of sales in the type of product which we have always made and which we fully understand?

4 If we secure the business of several of the smaller refrigerator manufacturers but are unable to secure any of the business of the larger ones, will the profits available from such business offset the costs of installing the tools and doing the experimental work necessary to enter this field?

How much more thoroughly must the executives of a company question themselves when they are thinking of diversifying into entirely unrelated fields, even though much of the manufacturing work on the new product can be done on the same machines that are already in use! There is no substitute for ample funds with which to rectify mistakes and bridge over lean years when diversifying These management problems help one to understand why large corporations are the most successful in consolidating units making diverse products and emphasize the fact that properly developed consolidations between two or more small companies are frequently more successful than attempts to expand the number of lines of products Only recently a company that has had phenomenal success in fork-lift trucks took over a company that manufactured large straddle trucks that lift entire piles of lumber and transport it, as well as another company that manufactures large cranes used in lifting dirt in excavations The parent company could have developed both of these new lines but elected to absorb going concerns rather than to start from scratch and to develop both the product and a sales force It is fairly well established, however, that a diversity of products, either through consolidation or otherwise, brings problems of managerial control that require careful decisions regarding organization and policy

Finance The problems of finance may be viewed from three angles (1) raising funds for the initial founding of the enterprise, (2) financing the "peaks and valleys" of a going enterprise, and (3) changing the financial structure of the going enterprise and securing funds for expansion Initial funds may be secured by the sale of common stock, preferred stock, bonds, some short-term borrowing, and other methods known to students of finance If the enterprise should prosper, it is quite possible that new plants, buildings, and equipment, as well as working capital, will be needed to care for the increased business Even though adequate funds are available from operating profits, a decision is required as to whether these funds are to be reinvested or are to be distributed to the stockholders, the needed funds being raised by selling additional stock or other securities There is also the question of the extension of credit to customers, which is basically one of finance

Profits may be high during a period of prosperity, and management may be forced to decide whether to distribute these profits as earned or to establish a policy of paying a moderate dividend during prosperous operations and build up a surplus with which to pay a dividend during lean periods Many other types of decisions that management will be forced to make are of a financial nature, such as whether to carry its own workmen's compensation insurance, whether to share profits with employees, whether to bear a part or all the expense of the group employee insurance, whether to establish an annual wage, and what provision to make for management profit-sharing and credit policies These problems involve factors other than finance, but all are also financial in nature A decision once made may not be final

Managerial controls The basis of managerial controls is managerial standards Managerial standards cover the entire range of business activity, finance, accounting, quality of product, organizational structure and procedures, requirements of divisional and departmental performance, executive remuneration in relation to profits, worker profit sharing where it exists, purchasing, and selling Managerial standards are basically the crystallization of managerial policies into formal measures and procedures An effective standard can be established only after careful investigation, analysis, consideration of the objective to be attained, harmonizing of conflicting interests, and agreement upon the basis of measurement Temporary standards may at times have to be established in the absence of all the necessary facts or in a situation where time does not permit the harmonizing of interests or agreement upon the common measure Such temporary standards, when established by persons having a broad background and keen insight, may develop into permanent standards when supported by experience Standards act as stabilizers of activities and

relationships Carefully established managerial standards are the foundation of the "exception principle" in management They relieve management of the responsibility of caring for many details and enable them to concentrate on problems that have not as yet been solved The details of standards are discussed under the various specialized chapters, such as those on equipment, product design, and time and motion study It is important, however, in the consideration of management decisions to observe that management standards are the foundation upon which all other detailed standards are based In the absence of seasoned managerial standards, departmental or functional standards are largely ineffective

Managerial standards are an expression of managerial policies and should grow out of these policies Some standards are in fact policies John G Glover has listed the characteristics of business policies as follows

1 It must delineate clearly the objective from which it is derived
2 It must be in understandable writing
3 It must prescribe criteria for current and future action
4 It must be stable but amenable to change, consistent with economic conditions and business requirements
5 It must be a canon from which precepts of conduct can be derived
6 Its edict must be capable of being accomplished
7 It should prescribe method of accomplishment in broad terms, but allow for the discretion of those responsible for preparing the precepts of conduct
8 Its derivative rules of conduct must not be subject to the discretion of those who are governed by them [3]

Glover further states that policies, to be wise directives of management, should conform to these criteria

1 Policies should express the philosophy of the company
2 Policies should imply a code of ethics expressing trustworthiness and result in cooperation
3 Policies should supply the bases for planning resulting in coordination
4 Policies should be the foundation for continuity of performance
5 Policies should supply the criteria upon which to appraise the wisdom of executive decision
6 Policies should outline intent, resulting in uniformity of practices
7 Policies should inspire confidence
8 Policies should afford bases for economy of action
9 Policies should provide bases for impartial objective management
10 Policy derivative precepts of conduct should furnish means of communicating the tenets of policies to company personnel [4]

Summary Managerial decisions involve every phase of the directing of the activities of the business as well as the creating of the initial business itself Plant location is a basic decision that is discussed in detail in

[3] John G Glover, "Management Policy," *Advanced Management,* March, 1953, Vol 18, No 3, pp 24–27, New York, Society for Advancement of Management

Chapter 11 Decision making in a successful business requires courage to assume the responsibilities of failure After an enterprise has become well established, there is a background of tradition and success that contributes greatly to decision making In such a situation most decisions are the result of group action rather than the responsibility of one or only a few persons

4 ORGANIZATION DEVELOPMENT

The functions of an executive Planning, organizing, and operating are the primary functions of an executive These functions may be illustrated by Fig 4 1 The sides of the equilateral triangle represent these basic functions of an executive Planning is in terms of objective Planning in this sense refers to the over-all planning, an administrative function, not the detailed planning of operations Operating refers to the regulatory activities of top management which are largely executed through organization channels Operating consists of initiating action according to plan within the framework of the organization structure and checking to see that the results conform to the plan and objective Organizing is for the purpose of creating relationships that will minimize friction, focus on the objective, clearly define the responsibilities of all parties, and facilitate the attaining of the objective Organization is the foundation of most of the steps of operating management Much of the criticism which has been leveled at certain methods of management in particular enterprises should instead be aimed at the faulty organization that made impossible the laying of the groundwork on which these methods should have been based Organization is not an end sought in and of itself but rather a means to aid in the attainment of the institutional objective Defective organization creates an unnecessary drag on the efforts of the members of a group striving to accomplish a desired result A sound organization structure creates an atmosphere in which both personal and group satisfactions may be realized, cooperation is encouraged, morale and the "will to do" are substituted for detailed orders, and the group moves smoothly and resolutely toward its goal

Definitions Organization may be conceived either from the standpoint of structural relationships between functions or from the standpoint of the people in relation to each other in discharging their functions [1] *In its broadest sense organization refers to the relationship between the vari-*

[1] See E H Anderson and G T Schwenning *The Science of Production Organization* John Wiley & Sons New York, 1938 pp 9–15, for a detailed discussion of the various usages of this term

ous factors present in a given endeavor Thus land, labor, capital, and the entrepreneur may be combined in various relationships to produce an economic organization Factory organization concerns itself primarily with the internal relationships within the factory, such as responsibilities of personnel, arrangement and grouping of machines, and material control

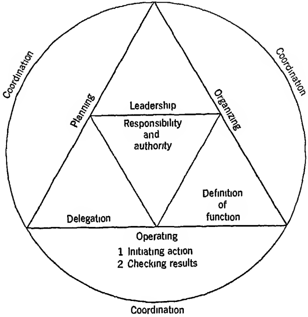


FIG 4 1 Functions of an executive planning, organizing, and operating The central triangle represents the core of an organization Authority arises from responsibility Responsibility is discharged through leadership Leadership is multiplied through delegation and defined through functional definition Coordination is the process of tying together or synchronizing all the efforts of management

From the standpoint of the enterprise as a whole, *organization is the structural relationship between the various factors in an enterprise* Organization is sometimes used to refer to the personnel functions within a given structural setup or to the functioning unit as a whole These two uses of the word seldom cause any great confusion

System is subsidiary to organization and *arises when procedures have been standardized* It is the crystallization of procedures whereby the efforts of men and departments are coordinated and integrated System is *regulatory in nature* and not within itself constructive, although it may be a means of simplifying constructive effort System is not an end in itself and must be carefully used if it is not to develop into *red tape*

Basic organizational considerations Organization carries out its purpose by determining the scope and limits of each individual or group of individuals in a business undertaking, together with their relationships and contacts with each other After considering the fundamentals and types of organization, an executive builds up a structure for his business or department which is peculiarly suited to its needs The application of the fundamentals of organization will differ widely in two different businesses The size of a business, particularly, has an effect on the way in which the organization develops On the whole, in the small business it is possible to develop essentially the same type of organization as in the large business, except that the duties of several people in the large business will necessarily have to be combined in the small one Organization should be dynamic, it should be changed to meet changing conditions

Organization building, of necessity, takes into consideration the different requirements of different types of business Steel plants textile mills, paper mills, or refining plants, although they have the same fundamentals to deal with, will adjust their organization structure to meet their specific needs In a manufacturing business, if the product is standard, ordinarily the organization will need to be differently constructed from one handling a diversified product The same amount of business may be handled with fewer chief executives if the product is standard, because it is easier to delegate authority in such industries Even the location of a plant or of the departments within a plant may affect the exact way in which the organization is constructed The effect of location on the personnel may demand this adjustment The primary fundamentals of organization should be considered by the executive in building the organization The operating fundamentals should be developed as an extension of the primary fundamentals of organization The primary fundamentals of business organization deal with those phases of management which include policy formulation and organization structure The operating fundamentals deal almost entirely with the operating phase of management

The primary and operating fundamentals of organization The primary fundamentals are fourfold

1 Regard for the aim and objectives of the enterprise

2 The establishment of definite lines of supervision within the organization structure

3 The placing of fixed responsibility among the various persons and departments within the organization

4 Regard for the personal equation

The operating fundamentals, which are also four in number, are

1 The development of an adequate system

2 The establishment of adequate records to implement the system and to use as a basis of control

3 The laying down of proper operating rules and regulations within the established organization in keeping with the established policies

4 The exercise of effective leadership

The first of the primary fundamentals, regard for the aim of the enterprise, serves to tie the developed organization closely to the determination of major policies, which is the first of the three major tasks of management Through the construction of an effective organization, major policies are followed in operations

Regard for the objectives of the enterprise The objective, if clearly formulated, provides a compass for developing the organizational structure at the time of its founding or a beam to chart its safe course throughout its existence Let us consider the organization which is necessary to take care of the unusual situation in which speed of attainment and not cost is the dominating factor Such an instance is clearing a railroad right of way after a wreck All thought of cost is thrown aside, and an organization is constructed which has but one end in view, namely, clearing the tracks and letting the trains through at the earliest possible moment Compare this to the organization necessary for the operation of a huge manufacturing plant which is to remain in existence for many years and whose activities are not only numerous but varied and must all be carried on with due relation to each other The organization structure required to meet the emergency of the railroad wreck will be simpler and more direct than that required to carry on the work of the manufacturing enterprise Length of life of the organization and desired speed of results are important factors in the development of its structure Thus, the organization necessary to construct a number of reviewing stands for a large parade, which will be put up quickly and taken down promptly, may be far simpler than the intricate organization of a construction enterprise involved in putting up a huge office building or hotel As the purpose for which or the condition under which the enterprise operates changes, the organization must likewise change

Definite lines of supervision Every employee in the enterprise has a right to know to whom he is responsible and for what In laying down the lines of supervision, the organizing executive has two main problems at hand First, he must determine the type of organization to be used The particular types of organization structures are described in Chapter 5 Second, he must carefully develop and mold the outlines of the type as they can be best applied to his particular business enterprise In developing his definite lines of supervision he will have to give careful attention

to the fourth primary fundamental, regard for the personal equation A lack of definite lines of authority will result either in an overlapping of duties or in gaps which are not taken care of On an organization chart such gaps or overlaps may be thought of as *horizontal* and existing between the lines of authority which have been laid down, as contrasted to *vertical* gaps or overlaps, which will occur if the third of the primary fundamentals, namely, the placing of fixed responsibility, is not adequately handled Lack of definite lines of authority will result in dissension among whole departments of the organization, and thus the personal attention of chief executives must be directed to the problems that arise [2]

Definiteness of control through the establishment of lines of supervision implies the idea of the scalar principle or *tapering authority* It implies the development of a group of executives in accordance with the plan of supervision, each one down the line having somewhat less authority in scope and somewhat more direction of detail At every step in the scalar chain of supervision there should be someone in charge The organization structure should also provide for someone to take the place of the regular supervisor when he is not available because of vacation, illness, death, or resignation In small businesses the desire to have a substitute for each executive sometimes has led to a surplus of executives It is never profitable to carry this idea to the point where additional executives must be put on the payroll This consideration is often a real one, as, particularly in small businesses, there is often a wide difference in caliber between the executive head of a department and anyone else in his department Lines of supervision should, as far as possible, permit specialization with all of its attendant advantages Definite lines of supervision reduce conflicts, serve as a basis of promotion, facilitate budgeting, and improve cost control

Fixed responsibility When a man knows his exact responsibilities, he is in a position to concentrate his efforts on meeting the requirements of his position It tends to promote a high morale for he receives full recognition for his achievements It facilitates the evaluation of performance and serves as a strong stimulus to perform Functional definition of the exact area for which an executive or worker is responsible is the third step in the *scalar principle* [3] Standard practice instructions setting forth in detail the exact limits and responsibilities of each job and position are part of an efficient organization structure It is sound procedure to *fix responsibility*

[2] See James D Mooney and Alan C Reiley *The Principles of Organization*, Harper, New York, 1947, Chapter III, for a scholarly discussion of the scalar principle

[3] James D Mooney and Alan C Reiley, *The Principles of Organization*, Harper, New York, 1947, p 14 Mooney and Reiley list leadership, delegation, and functional definition as the three factors in the scalar principle

as far down in the organization as competence and the necessary information exist Definite fixing of responsibility has the following advantages

1 Fixed responsibility acts as an incentive to a subordinate This is particularly true in large organizations

2 Fixed responsibility aids in the general speed-up of work It immediately becomes possible to know to whom communications should be addressed or which executives should be called into conference on any particular topic

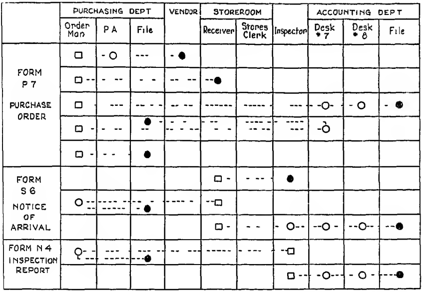
3 Accurate placing of responsibility assists in developing discipline as a means of control

Regard for the personal equation Consultive supervision takes the personal equation into consideration Recognition of the dignity of the individual definitely influences the effectiveness of an organization structure In developing lines of supervision and in fixing responsibility, it is necessary to consider the personnel which is available or can be made available Frequently men have been shifted in an industrial organization as if they were all of equal value, as if one could readily replace the other, or as if one could always fit into an organizational niche when another had gone merely because he was a man of approximately the same salary or had previously performed almost the same duties Men are of different values and work together in different ways Merely assigning duties to men does not lead to the accomplishment of tasks, and therefore it is not always possible to draw organization charts and find men to fit them The scientific manager will either train his men to meet the standards of the desired organization or will seek them on the outside At a given time, however, compromises may have to be made

Some enterprises with branch establishments have organized each branch in exactly the same way, having for each branch organization charts which are exactly the same In some of the branches it will be found that everything is working smoothly and that everyone cooperates with everyone else, whereas in other branches jealousies have arisen, dodging responsibilities is prevalent, and the organization seems to be generally ineffective The main difficulty is that although the organization has been outlined, the lines of supervision have been drawn, and the responsibilities have been fixed, the personal equation, the abilities and limitations of the men and women, has not been taken into account Proper consideration must be given at times to home conditions and outside worries It is well enough to say that men and women should keep their social affairs outside the business, but unfortunately human nature frequently does not permit this The habits and inertia of the personnel of an organization must be considered For just this reason new organizations are easier to construct than are old organizations to reconstruct The "efficiency man," who developed so much trouble for himself, frequently did so because he refused to consider

the habits or inertia of personnel involved They gave lip service to the suggested changes but did nothing about putting them into practice

Adequate system System is not an end in itself but a means to an end Systems may contribute to efficiency but too much system becomes red tape System is a strong instrument of control Although system implies order in work, it does not necessarily imply economy A procedure may be highly systematic but still be very wasteful Balance is needed in the establishing of systems as well as in all other managerial activities



ROUTING OF PAPERS – PURCHASE ORDER PROCEDURE

□ Originates ○ Action to be taken ● - Action completed

FIG 4 2 A procedure chart

System is a part of organization, not the whole of it As an operating fundamental it helps to bind the whole mechanism of organization together System is the existence of order and method in all parts of an undertaking System implies a formalized procedure that is to be followed in the handling of standardized activities (Fig 4 2) It relieves the man at the head of the details of execution and is a bulwark that prevents the lines of authority which have been laid down from being overstepped It insures that work will be brought to executives with the preliminary steps completed and ready for their attention, thus enabling them to apply their entire time to matters of maximum responsibility When all factors in a business are moving in a regular and accustomed routine, the waste of time

and effort involved in repeating the preliminary steps of the solution of any problem is avoided

Standard-practice instructions When the system is extended to the place that standard practices have been established, it may well include organizational relationships as well as procedures To use standard-practice instructions to show the scope of authority of each of the members of an organization makes these instructions interpreters of the organization chart, if there is one [4] It is impracticable to show on the face of such a chart all the necessary facts These standard-practice instructions are not necessarily fixed, in fact, it is usual to find them under constant revision Their value is that during the periods of change existing relationships are maintained until they are superseded in written form by new information The value of standard-practice instructions, showing scope or lines of authority, is increased when functions are transferred from one member or department of the organization to another They are of great value in bringing changed conditions to the attention of all persons within the organization

Examples of standard-practice instructions might include instructions concerning the handling of complaints, instructions concerning action to be taken on certain paper work, or instructions concerning the method of estimating the demand for a new article or line to be added to those already manufactured by the company When occasion arises for the development of such instructions, the manager in charge of the function involved sees that the standard instructions drawn up clearly indicate the procedure to be followed The matter does not come to the executive's attention again until a change in the instructions becomes necessary In some companies all standard practices are issued from a central department that specializes in this work Even in this case the department concerned may initiate the action

Standard-practice instructions are advantageous and vitalize the development of the organization fundamentals within a business because

1 They are not likely to be misunderstood
2 They are less likely to be forgotten
3 They fix responsibility for mistakes
4 They clarify the ideas of those giving the orders and thus insure careful thought
5 They encourage change in methods that should be continuously improving
6 They expedite the routine to be followed by members of the organization
7 They constitute a ready-reference file of executive decisions

Standard-practice instructions have frequently failed in operation Their failure can usually be ascribed to one of several causes

[4] See Chapter 6 for illustrations of the organization chart

1 Too many orders
2 Not enough care in preparation
3 Occasional delegation of the preparation of the instructions too far down in the organization

Too many orders may be the result of one of two difficulties, either orders issued from too many sources, or too large a number of orders from one or more of these sources Nothing will break down the force of standard instructions more than to have two conflicting instructions, both supposed to be binding The effect of too large a number of orders is almost equally bad The second chief reason for failure is lack of sufficient care in preparation Such lack of care may include either the use of terminology that is not clear or failure to visualize all the implications involved in the order being transmitted The third reason for failure of standard-practice instructions is that some person too far down in the organization scale is delegated to prepare them This situation defeats much of the purpose of standard instructions, which is to insure at all times chief-executive direction, together with the operation of the exception principle

The exception principle in management In discussing the exception principle Frederick W Taylor said

> Under it the manager should receive only condensed, summarized and invariably comparative reports, covering however all of the elements entering into the management, and even these summaries[5] should all be carefully gone over by an assistant before they reach the manager, and have all of the exceptions to the past averages or to the standards pointed out both the especially good and especially bad exceptions thus giving him in a few minutes a full view of progress which is being made, or the reverse, and leaving him free to consider the broader lines of policy and to study the character and fitness of the important men under him[6]

Operating under the "exception principle, frequently recurring matters are made routine, a system of checks and balances having been developed in accordance with responsibilities already fixed, so that these matters may be handled entirely without reference to the executive himself Through the operation of the exception principle all routine matters may be handled by the executive in a few minutes, and thus he is enabled to devote his entire time to the more important matters which should demand his personal attention He may devote more detailed consideration to the peculiar cases that do not fall under the routine In devoting his attention to these matters, he frequently correlates them and develops the points of

[5] The executive must exercise care not to have this editing process function in such a manner as to keep from him vital information about employee unrest and similar items Sometimes his assistants think that he should not be bothered with such details which however, are often more important than other items reaching his attention

[6] Frederick W Taylor, *Shop Management*, Harper, New York, 1911 p 126

similarity and difference among them, until they, too, are classified and routine and no longer may be termed exceptional

Systematic management In systematic management considerable attention is devoted to all the fundamentals of organization, the greatest being given to the execution of orders through the development of a complex but generally effective system It is in this type of management that the importance of the office clerk and bookkeeper reaches its peak, as compared to the situation under the thoughtful direction of the real executive Systematic management represents a rather full development of system within an organization, without a corresponding development of the more thoughtful processes associated with scientific management In plants where this type of management is found the executives are methodical in the extreme, and in some departments the smoothness of operation is very high

Reports as a basis of control A report in part discharges the responsibility of a subordinate to his chief It is the completion of a task, the end of an assignment of work to be done Just as an order should communicate all information necessary for execution, so a report should contain all the data essential to appraisal of performance The primary requisite of a report is that it serve a really useful purpose Some men require the submission of reports which are of little practical value If reports are to be an aid to the operation of the exception principle, this situation must be avoided Otherwise the reports will not be read and will not serve as the basis for action The ability to prepare a concise report which comes directly to the point at issue, covers all the necessary facts, and at the same time does not waste space by the inclusion of nonessential details is the best possible evidence that the subexecutive has an understanding of his work, has completely thought through and analyzed the situations that have confronted him, and, in short, has successfully mastered his job and is the type of person to whom more responsibilities may be given

Reports to executives should always be concise, should give the general facts and basic conclusions, if any, in the first few paragraphs, and then should follow them with such elaboration and data as are necessary in the particular case at hand In a more comprehensive report, such as an economic survey, it is advisable to include *a summary and conclusion* as the first chapter of the report This section is somewhat more condensed than the summary at the end of the report, but it should include the important conclusions All information that is susceptible of comparative treatment should be so handled, that the executive may see trends without having to look up previous reports or other older information This comparison may be accomplished by the use of graphs or comparable statistical data Statistical reports, to be effective in the development of system, must readily

call the attention of the executive to unusual figures but should not draw his attention unduly to figures that may be considered normal. Organization reports may be periodic or special. Special reports are prepared on some unusual subject by special assignment. Periodic reports are regularly presented at stated intervals.

Records. Records should give the facts concerning the operation of the enterprise. Their preparation and use make possible the elimination of guesswork for management. Good organization requires adequate records. Too few records are costly, too many records possibly even more so. Once the necessity for records is realized by those in charge of the enterprise, the immediate danger is the development of "red tape." "Red tape" is of three general kinds: (1) too many records, including some unnecessary ones and duplicates made up by different departments, (2) too many forms to secure essential information which might be obtained on a smaller number by combining several, (3) the unnecessary refinement of information. Ordinary processes of manufacture, distribution, or management may easily be halted to secure accurate figures when approximate information would serve the needs of the executive. A multiplicity of forms results in frequent loss and consequent absence of necessary information because one of many forms relating to a particular problem is not at hand. Forms should be of standard size wherever possible[7] in order that their handling, as well as their filing, may be expedited. They should be constructed so that they are read easily, with the most important information standing out most prominently when the form is filled in. An integral part of keeping adequate records is to maintain them so that they are readily available when needed.

One sound maxim concerning records, as well as other devices of *management*, is that *they are valuable only to the point where the cost of their collection is less than the savings which they will effect*. Many interesting data can be collected at large cost. If the executive is of the type who likes to know the detail of operations from every possible angle, it is not difficult for him to secure the information. It is likewise not difficult to increase the overhead cost of the business tremendously.[8] One type of record which usually justifies its cost of collection, however large, is cost records, if their value is determined in broad rather than in narrow terms. Proper cost analysis gives invaluable data on conditions demanding reorganization. The larger and more complex the organization, the greater is the importance of securing accurate cost records. It is essential that all records of

[7] For example, 3 x 5, 4 x 6, 5 x 8 or 8½ x 11 inches.

[8] The use of machine-kept records, especially the tabulating card, may simplify record keeping and greatly reduce the cost of compiling many details that would otherwise be almost impossible to accumulate.

whatever nature, be compiled so as to indicate trends Records, like reports, which do not give comparative information frequently are valueless Certainly the records that include comparative information are far more valuable than those that do not

Operating rules and regulations Operating rules and regulations define the scope of the application of system to the various portions of the lines of authority which have been built up They provide methods for the utilization of the records, and in innumerable ways function to knit the organization together into a unified whole The establishment of exact rules, either verbal or written, facilitates the delegation of authority and responsibility and permits system actually to work, because *the superior and the subordinate both have a definite concept of their respective duties and responsibilities* Written rules and regulations may be general in nature, touching only the broad outlines of business policy, or they may be more detailed, taking the form of a "standing order," which may provide the exact method of performance of nearly every task in the business In developing rules and regulations, care must be taken to insure that they are amended as conditions change and that they are not so detailed as entirely to eliminate individual initiative and its good effects from the business An operating manual exerts a stabilizing effect upon the organization and serves both as a guide to performance and a standard against which to measure accomplishment

Proper rules and regulations should be established to minimize direct supervision and order giving and to give stability and a measure of security to the group Unless written rules are orally and intelligently interpreted at the time of their promulgation and the spirit behind them is clearly defined, it is likely that too often they will be observed according to the letter of the rules in situations when the interpreter of all business regulations, judgment, should be exercised Rules and regulations include proper instruction of the personnel in all features of the business

Dynamic leadership Dynamic leadership is the cornerstone on which the entire managerial process rests Dynamic leadership may achieve a high degree of success in the face of considerable drag of organizational structure weakness On the other hand, an ideally conceived organizational structure may be impotent in the absence of a dynamic leader No company or service can rest on its laurels Dynamic leadership does not come naturally to the great mass of officers and executives It is achieved through the example and training provided by a few outstanding personalities A dynamic leader can get results with defective organization structure An ideal organization structure may become sterile in the hands of defective leadership The operating executive spends most of his time in detailed planning to carry out the major plans of top management, organizing to

effectuate the institutional objectives, and exercising supervisory control over his subordinates His organization task, although equally important, is not the one to which he devotes the majority of his working hours The task of supervision or leadership consumes most of his time and consists, in the main, of making decisions and handling exceptional cases, as they arise, in a way that will promote the smooth operation of the organization In carrying on this work, the executive, if he is capable, will at the same time provide inspirational leadership for his subordinates

The organization builder should beware of the "strong man" in a well-established enterprise The so-called "strong man" is a man at or near the top who brushes aside the carefully developed lines of supervision or responsibilities which have been fixed and, through his own dynamic guidance, operates the organization or a large part of it Such men are dangerous in long-enduring organizations because they tend to trample on the feelings and rights of others, destroy morale, and ordinarily, if they resign or die, cannot be replaced However, when policies are being determined in new businesses, such a driving head is often superior, for purposes of getting an organization going, to a group of individuals without his driving power, even though they may work along theoretically correct lines of authority and responsibility The combination of a strong driving force from the top combined with observation of well-developed fundamentals of organization through the ranks is one of the best, if not the best means of effective leadership that can be developed

Figure 4 3 illustrates the division of activities and interests of officers, executives, and supervisors in a given line authority The efficient executive plans the work for his subordinates, coordinates their efforts, and provides the dynamic leadership that inspires them to increased effort

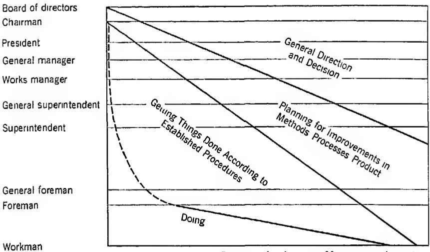
Poor leadership is easily observed, it is evident in the executive who is unable to get rid of the matters which come to him for decision, in the man who makes snap judgments, in the man who shows his ignorance of the relationships of the various other phases of the business to his own, or in the man who treads solely the path of custom

The span of control No single executive should have more people looking to him for guidance and leadership than he can reasonably be expected to serve The number of cross relationships rises geometrically as the number of persons reporting to one person increases With 5 persons reporting to 1 head there are 41 direct, cross, and group relationships requiring coordination, this rises to 1068 when there are 10 persons reporting to 1 head [9] The more highly trained each of the subordinates is, the less direction that is required and hence, the larger number of persons a

[9] See R E Gilmore, *A Practical Manual of Organization*, Funk & Wagnalls, New York, 1948, p 12

leader may have reporting to him at the top echelon A survey by the American Management Association showed that of 100 companies of 5000 or more the median number reporting to the president was 9 Of 41 medium-sized companies (500–5000) the median was between 6 and 7 [10] At the lower echelons in repetitive operations the number of persons that may be supervised varies from 10 to 30

One must not confuse the fact that some executives have large numbers of persons reporting to them with these executives giving real direction to



Courtesy, the American Management Association

FIG 4 3 Chart illustrating the division of activities and responsibilities of officers, executives, and supervisors (Adapted from American Management Association, *Personnel Series*, No 24, p 33)

these large numbers If the reporting executives are of high caliber and are supported by a long tradition, they may operate almost as independent executives A college president recently took over his new duties and found that he had 32 different bureaus and separate committees reporting to him in addition to the various deans and other administrative officers His predecessors had made no attempt to give direction to this large number of activities He merely approved their budgets The new president's first efforts were directed toward reducing this unwieldy organizational structure to a size to which he could really give direction One of the basic causes of the excessive number of people reporting to a top executive is the desire of so many people to report only to the chief executive officer

[10] *Management News*, July 31, 1951, p 3, American Management Association, New York

5 TYPES OF ORGANIZATION

Organization objectives Organizing is for the purpose of creating relationships that will minimize friction, focus on the objective, clearly define the responsibilities of all parties, and facilitate the attaining of the objective A sound organization structure creates an atmosphere in which both personal and group satisfactions may be realized, cooperation is encouraged, morale and the "will to do" are substituted for detailed orders, and the group moves smoothly and resolutely toward its goal Defective organization creates an unnecessary drag on the efforts of the members of a group striving to accomplish a desired result The structural relationships among the various factors of an enterprise contribute to the smooth functioning of the enterprise provided it is constructed along well-established principles If fundamental principles of organization are violated, friction is certain to develop, morale is depressed, and the general effectiveness of the group is lowered One basic principle of organization is specialization of effort, or the grouping of related activities together This is also known as the principle of functionalism [1] (It should not be confused with Taylor's functional organization)

Line or scalar organization In the line, scalar, or military [2] organization authority flows directly from the boss to various subexecutives in charge of particular phases of the business and from them to other workers In the simplest form of the line organization the boss is in direct authority over all the workers in the organization except certain of the factory workers who might be under a foreman Figure 5 1 illustrates this type of organization There are two types of line organization (1) pure and (2) departmental *Pure line* organization is found only where the activities at any one level

[1] A function is any activity that can be clearly differentiated from other activities Functionalism in top organization consists in the dividing of the enterprise into its organic functions of finance, sales, manufacturing, and sometimes engineering and personnel Each of these broad functions may be divided into many minor functions

[2] The line organization is also called the military type of organization When thus used military has no connection with methods or organization in the armed services today It refers rather to the straight flow of authority within a single unit, sometimes called the scalar type

are the same, with each man performing the same type of work, and the divisions existing solely as a basis of control and direction A group of 100 house-to-house salesmen might be organized on this basis In the *departmental line organization* the respective workers and supervisors are

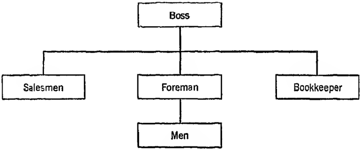


FIG 5 1 Simple line organization for a very small enterprise

grouped on a functional basis, such as sales, manufacturing, engineering, and accounting (See Fig 5 2)

Line organization is direct, and the members know to whom they are accountable, it is simple and easily understood, flexible and able to expand or contract readily, strong in discipline through the fixing of responsibility,

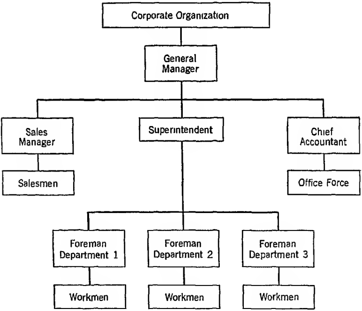


FIG 5 2 Line organization chart

and capable of developing the all-round executive at the higher levels of authority On the other hand, the line organization overloads a few key executives, encounters difficulty in getting the executives at the lower levels to grasp the need for coordination, makes little use of the principle of specialization, and requires a high type of supervisory personnel to carry the burdens imposed in the absence of specialists as advisors If a strong man capable of carrying the load is available, at times when competition is keenest it may be desirable to fix responsibility for a department entirely on one man and to allow him to develop a strictly line type of organization within his department, so that results may be prompt and responsibility for them may be fixed Military organizations can have their heads changed more readily, little coordination being needed within them, since responsibility rests clearly at the top It is perfectly possible to develop some departments on a line-and-staff basis and others, where suitable conditions exist, on a military basis, in order to secure the advantages of both types of organization

The functional type of organization Frederick W Taylor conceived the functional type of organization as a means of overcoming the difficulties in finding the all-round men qualified to be foremen in the old line organizations He replaced the general foreman with four functionalized foremen Taylor said, "It is because of the difficulty—almost the impossibility—of getting suitable foremen and gang bosses, more than for any other reason, that we so seldom hear of a miscellaneous machine works starting out on a large scale and meeting much, if any, success for the first few years " He further stated

> This difficulty is not fully realized by the managers of old and well established companies, since their superintendents and assistants have grown up with the business, and have been gradually worked into and fitted for their especial duties throughout years of training and the process of natural selection Even in these establishments, however this difficulty has impressed itself upon the managers so forcibly that most of them have of late years spent thousands of dollars in regrouping their machine tools for the purpose of making their foremanship more effective The planers have been placed in one group, slotters in another, lathes in another etc so as to demand a smaller range of experience and less diversity of knowledge from their respective foremen [3]

In the scalar or line organization the foreman is held responsible for the successful running of the entire department The foreman under this system of organization must lay out the work for the whole department, seeing that each piece goes in its proper order to the right machine, that there is a man at the machine to do the job when it gets there, and that he knows just what is to be done and how he is to do it The foreman

[3] Frederick W Taylor, *Shop Management* Harper, New York, 1911, p 93

must see that the work is done correctly, is not slighted, and is done promptly He must look well ahead, possibly a month or so, to determine what the demands on his shop will be at that time He may have to provide more men to do the work, or he may have to try to secure more work for the men to do The disciplining of the men is entirely the responsibility of the foreman, as are all relationships between the firm and the men on the subject of wages, including the supervision of timekeeping, the fixing or recommending of piece rates or day rates, and the readjustment of these from time to time Each day he must decide, on the basis of his own judgment, just what small part of the mass of duties in front of him it is most important for him to attend to He does a fraction of the work for which he is responsible, leaving the rest to gang bosses and workmen to do as they may see fit

Taylor said that the well-qualified foreman required, "brains, education, special or technical knowledge, manual dexterity or strength, tact, energy,

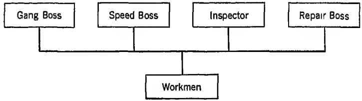


FIG 5 3 Functional organization chart, showing Taylor's shop bosses

grit, honesty, judgment or common sense, good health " He believed that a man with three of these qualities could be hired at any time for laborer's wages If four were required, it was necessary to secure a higher-priced man The man combining five of the qualities was hard to find, and the one with six, seven, or eight almost impossible to discover

Taylor felt that functional foremen, each with but one type of task, would need but four or five of the attributes which he had outlined and that such men could be found Under functional foremanship each workman, instead of coming into direct contact with but one supervisor, would receive his orders from a group of specialized supervisors, each of whom performed a particular function (Fig 5 3) Because of this feature, functional foremanship was never generally adopted, although the development of staff or functional departments to deal with particular phases of the business and to relieve general supervisors of these phases was a direct outgrowth of the problems of military foremanship, as influenced by Taylor's functional idea In *Shop Management* Taylor set down the proper number of functionalized foremen as eight, four of whom were engaged in general planning work "These four representatives of the planning de-

partment are, the (1) order of work or route clerk, (2) instruction card clerk, (3) time and cost clerk, and (4) shop disciplinarian " [4] The four foremen in the shop were to help the men personally in their work, each boss assisting only in his particular function. Some of these bosses came into contact with each man only once or twice a day, and then for only a few minutes, whereas the others were with the men constantly and helped each man frequently There was no specific group of workmen falling into varying groups for supervision purposes but organized into given departments for production purposes

Taylor's functional foremen's duties may be described as follows The *gang boss* has charge of the preparation of all work up to the time that the piece is set in the machine It is his duty to follow up the plans of the planning men and to furnish all the jigs, templets, sling chains, and other necessary adjuncts for each operation The gang boss shows his men how to set up their work in their machines in the quickest time and sees that they do it He is responsible for the work's being accurately and quickly set and should be not only able but willing to show the men how to set the work in proper time This man has nothing to do with the running of the machines, and his job is completed when the work is set up in the machine The *speed boss* sees that the proper cutting tools are used for each piece of work, that the cuts are started in the right part of the piece, and that the best speeds and feeds and depth of cut are used His work begins only after the piece is in the machine and ends when the actual machining ends The speed boss not only advises his men how best to do the work, but also sees that they do it in the quickest time, and that they use the proper speeds of the machine and so set their tool that they secure the proper depth of cut He may be called upon to demonstrate that the work can be done in the specified time, by doing it himself in the presence of his men "Speed boss" refers to supervision over proper speeds and not to an attempt to 'speed up" the workman This man has recently been called an 'instructor" rather than a "speed boss " The *inspector* is responsible for the quality of the work Both the workman and the speed bosses must see that the completed work is up to specifications in order that it may be passed for quality by the inspector The inspector should be a complete master of the machines himself and be able to do the work quickly and well Under such circumstances his rejections will be more readily accepted by both the workmen and the other bosses in the shop The inspector always sees that the first piece made up is of the

[4] Frederick W Taylor *Shop Management* Harper, New York 1911, p 102 It will be well for the student to recall that the modern cost department is the successor to Taylor's cost clerk and that the present personnel department is the outgrowth of the shop disciplinarian

proper standard in dimensions, fit, and finish. He also makes further inspection from time to time to see that the standard is maintained. The *repair boss* sees that the workman maintains his machine and work place in proper condition. This maintenance includes cleaning the machine, keeping it free from rust and scratches, oiling it properly, and preserving the standards which have been set up for the auxiliary equipment connected with the machine, such as belts, countershafts, and clutches. Keeping the floor around the machine clean is also a task under the supervision of the repair boss.[*]

Serving two masters. Taylor's functional type of organizations had the workman taking orders from as many as eight different foremen. There is a very deep-rooted conviction in the minds of many that no man can work under two bosses at the same time. The thought that a workman could not serve two masters prevailed, and today we find, not functional foremen, but rather functionalized staff departments, working through one foreman. In summarizing Taylor's idea of functional supervision the advantages may be listed as follows:

1. Specialized skills are brought to the individual workmen.
2. It is possible to find supervisors in sufficient numbers who possess the required abilities.
3. The separation of manual from mental work takes advantage of the principle of specialization.

The major disadvantages of functional organization are:

1. It tends to complicate problems of discipline among the lower levels of the organization.
2. Coordination of the efforts of the various functional foremen is difficult. (Among major executives this is not so great a problem.)
3. Such organization tends to narrow specialization among executives and workers.

The line-and-staff organization. The staff relationship arises when the line officer has more specialized duties to care for than he is capable of handling. If it is merely a larger number of duties, the line supervisors are increased. In the case of special requirements the aid is given through a staff aid that does not operate in its own name but in the name of the line to which it is attached. A distinguishing characteristic of a staff function is the fact that it is a service that aids the line organization in the performance of its major activities. Nearly all of the staff activities at sometime were performed by the line officers in small organizations. The staff brings specialization to the assistance of the line organization. Staff officers should ever remember that theirs is a service function even though

[*] Much of the material in the preceding paragraphs is adapted, by permission, from *Shop Management*, by Frederick W. Taylor, Harper, New York, 1911.

they may be delegated certain control duties by the central line authority This recognition by the staff influences the attitude of staff people and such an approach promotes cooperation with the line Line officers and supervisors should recognize that management has assigned certain service functions to the staff as an aid to over-all efficiency of operations This attitude on the part of staff officers will smooth the relationships between them and the line officers

Figure 5 4 shows a simple development of line and staff in the production and sales departments of a business The functions marked X are staff

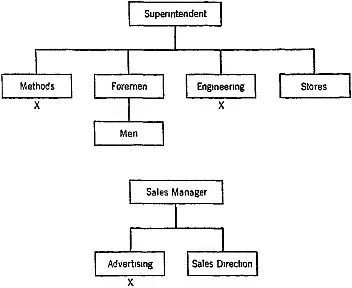


FIG 5 4 Line-and-staff organization

In the manufacturing division of a business the functional departments guide and to some extent control the foremen The organization is so constructed that the foreman can retain his one-man control over the men under him and at the same time can have his direct responsibilities reduced to a point within the range of accomplishment The foreman's primary duty is leadership and under this plan of organization he can better perform this function The functionalized staff departments give technical operating information and orders to those in direct charge of the workmen In the sales division of a business the functional staff departments do not direct the operating or sales activities but perform some specific staff function, such as advertising, which is of direct assistance to the line members of the organization in better performing their duties There may also be functional staff departments in the financial division

In an operating organization it is more important that the line-and-staff idea be utilized in the setup of the organization than it is that each individual's duties be clearly line or clearly staff Some persons will have their duties develop so that they will be in some respects line and in other respects staff A top line man usually controls more than one particular function of the business and has under him workers who are directly productive[6] A staff man usually controls but one function of the business, and workers who are directly productive do not ordinarily report to him Departments are line or staff, as their heads fit into one or the other of these categories It may well be observed, however, that a staff department may itself be organized on a line basis The accounting, personnel, and methods departments are functional staff departments, which render a service to the main productive unit of the enterprise The line-and-staff organization has practically all the advantages of both the line and functional organizations with relatively few of their disadvantages At times the staff department may infringe upon the rights and responsibilities of the line organization, thus weakening the line organization when its true function is to strengthen this organization[7]

The staff officer Usually the staff officer has no administrative authority whatsoever but is an expert in some phase of the operations, he reports to an executive and gives advice on the subject of his specialty This specialty may be general administration, if the staff officer is an assistant to the president or an assistant to the general manager, or it may be statistics, finance, budgeting, law, or innumerable other fields Sometimes, for instance, in legal advice or budgeting, the work may be sufficiently heavy to permit the development of a staff department instead of an individual The great advantage of the addition of advisory free lances to an organization is that they are altogether free of administrative or managerial duties and hence are able to devote all their time to work in the field of their specialty

The committee Generally the joint advice of a group of men conversant with a subject is immeasurably superior to the ideas of one man or to any plan developed from a single individual's brain The best method of developing a proper group spirit is to get men together Their jealousies and their distrust of each other can be eliminated only by bringing them into close contact with one another The spirit of helping each other for the

[6] Productive" is here used in its popular sense of referring to work that is directly associated with turning out the product Strictly speaking, all work should be productive or else eliminated

[7] See William R Spriegel and Ernest C Davies, *Principles of Business Organization* Prentice-Hall, New York, 1952, pp 52–76, for a detailed discussion of the advantages and disadvantages of the various types of organizations and of the committee

good of the enterprise can best be developed in a conference The committee recognizes the human factor, fosters the spirit of cooperation, implants the new ideas of organization and its fundamentals in the minds of all members of the organization, and gives everyone the contacts necessary to perform his tasks properly On troublesome problems the committee secures the advice of those best qualified to aid It stimulates these men to give the company the best that is in them The standing committees solve routine problems of operation but also investigate and advise concerning policy and organization development

Securing cooperative effort through committee action requires the recognition of the following cardinal principles of cooperation

1 Consideration for the viewpoint of those persons who must execute the plan
2 Persons close to the details of operations may contribute constructive suggestions
3 Plans will be more effectively executed when the participants thoroughly understand all the causal relationships and factors involved

Committees may be divided into four general classes

1 The committee which has full power to act (Seldom found save at the top management level)
2 The committee which has limited power but whose actions are subject to veto (Not used extensively)
3 The advisory committee
4 The educational committee the class or discussion group

The advisory committee is used extensively in business It usually suggests courses of action to the chairman, aiding him in reaching the decisions for which he is held responsible He may accept or reject these recommendations, but, normally, matters will be thrashed out and the decision reached will be practically final The committee is a weak control device and a poor substitute for proper organization in the first place Most committees with authority incorporate an element of compromise which frequently does not represent the true facts of a situation except in the case of policy determination Unless committees are used wisely, they tend to waste the time of the members Committees are of great value as a means of coordinating the efforts of the departments which are represented They are also of special value in broad policy determination As a rule a committee is not well adapted to the collection of facts or technical data A member of the committee or an expert under the direction of the committee may collect the facts, and the committee may evaluate them or formulate a policy supported by them Such a policy is likely to be more inclusive and to consider the broader implications than a policy that is the work of a single individual In order not to waste the time of the com-

mittee members, the chairman should prepare an agenda that is sent to the members of the committee in advance of their meeting. If costs were accumulated regarding committee meetings, they would not be held so often.

The manufacturing committee The manufacturing advisory committee would include the *product engineer*, the *sales manager*, or the member of the production organization whose function is to effect liaison with the sales organization, the *head of the cost department*, the *general superintendent*, the *purchasing agent*, if purchasing is a major item, as well as the *director of manufacture*, who would preside over the committee's deliberations. Other men may be added to the committee when special items are considered. The production manager should sit in on the discussion of production schedules.[8] The director of personnel often is a member of this committee, as is the plant engineer if plant changes are being considered. The representative of the sales department need not sit in on the meetings of this committee where matters are being considered that do not directly affect sales. Other members of this committee need not attend its meetings when special items in which they are not interested are the major factors for consideration. A copy of the minutes, however, should go to every member of the committee. The secretary should not only preserve information concerning actions taken but also should straighten out many difficulties between meetings and have matters for the committee's attention in such shape that it will be possible to get them out of the way in minimum time at the meetings.[9] The work of the committee may include:

1. Plans to change the product, including a consideration of new methods of design or new items to be marketed. The interplay of sales and production factors must be considered here.

2. Progress that has been made on changes already begun. This is important, for otherwise it will be found that new ideas which have been decided upon and partially put into effect can be totally forgotten in the press of daily routine.

3. Consideration of methods of cost reduction. Reports by committee members upon economies, decided upon in previous meetings and assigned to them to put into effect, might be included. In this connection, when work of a specific department is taken up, it is possible and advisable to have the foreman in charge of that department in the committee meeting, whether or not he is regularly a member of the committee.

4. Coordination. A discussion of routine operation, the status of orders, causes of hold-ups, progress of manufacturing programs, and similar subjects.

[8] He is frequently a permanent member of the committee and often serves as its secretary.

[9] See Paul E. Holden, Lounsbury S. Fish, and Hubert L. Smith, *Top-Management Organization and Control*, McGraw-Hill, New York, 1951, pp. 59–73, for an excellent discussion of the uses and limitations of the committee. Every executive who uses a committee should read this section of the book.

Organization charts An organization chart strives to portray graphically the structural relationships between the various departments and positions in the enterprise Organization charts, like other diagrams, are not wholly satisfactory, inasmuch as many little details and interrelationships of live, operating organizations cannot be pictured Figure 5 5 indicates the organization of a relatively large enterprise, showing the various functional departments In small concerns, although the same functions may exist many duties will have to be combined The gigantic corporation, such as General Motors (Fig 5 6), has a more complicated organization in the upper brackets than that illustrated in Fig 5 5 This complexity is made necessary by the problems of coordinating the activities of the various divisions, each of which is a large enterprise in itself In practice there are innumerable exceptions to the exact positions of various departments assigned in Fig 5 5 Where product engineering is highly technical or the style element is of special importance, the product engineer often reports to the vice-president and general manager It is not at all unusual to have a plant engineer reporting to the general superintendent or the director of manufacture In such cases the power department and the maintenance department report to the plant engineer Other exceptions will be pointed out in later discussions

In carrying on his work the president is assisted by duly selected officers having control of certain parts of the corporate work such as the treasurer, in charge of company funds and financial policy, and the secretary, in charge of corporate records and stock transfer (Fig 5 5) The functions of the treasurer and secretary should not be confused with somewhat similar ones incident to the daily operation of the business In the type of organization being described these latter functions would be controlled by executives reporting to the president or general manager, who has charge of the operation of the business In many smaller concerns there is no president, but instead a general manager who reports directly to the board of directors, or the president and general manager may be the same person In such organizations the treasurer is in charge of the operating details of his division as well as the corporate work Thus routine accounting and record work would be under the control of the treasurer It is usual to have the secretary of the company keep only the corporate records regardless of the organization, in the small corporation however one person may be both secretary and treasurer

Divisions of an industrial enterprise Under the president general manager, or operating head of the enterprise, there is an immediate split into divisions [10] of operation, functional in form There is for instance,

[10] The terms "department and division' are frequently used interchangeably When a distinction is made, "division should represent the larger unit For in-

the *comptroller*, who deals with all office, accounting, and record operations, and in some cases finance, the *manager*, or *director of manufacture*, who has under his control all matters relating to plant operation and the manufacture of products, the *director* or *manager of distribution*, who controls sales, and, in many modern organizations, the *director of industrial relations*, who deals with all matters concerning personnel In this development of the main operating organization there are a small number of main divisions, which means that only a few persons report directly to the chief executive It gives the general manager an opportunity for real policy development, which he does not have if a large number of persons are reporting directly to him A necessity which is often overlooked is that of sometimes creating special temporary divisions for carrying on some unusual work Examples can be found in the creation of a "new building" division it a new structure is being erected for the business, this division having supervision over construction and movement into the new building, or in the creation of a "government work" division when government contracts are held by the business

The comptroller's division The comptroller (or treasurer in the smaller organization) has under him certain staff heads each controlling the operation of one phase of the office work These men are the office manager, in charge of the general office operation, the credit manager, in charge of the granting of credits and the collection of accounts receivable, the chief accountant, and the chief statistician A separate section is set up under the chief accountant to handle costs (This is a particularly important phase of manufacturing accounting The collection of cost information is often regarded as a production function and may be placed in the hands of the planning department, under the production manager) There must of necessity be some tie-up between the distribution division and the credit man under the comptroller By placing on the credit committee a representative of the sales department, such a tie-up can well be secured

The sales division The organization of the office of the director of distribution will be found to vary considerably with the selling problems involved in different types of enterprise Where advertising is the major factor in selling, as in tooth-paste industries, the advertising division may not be under sales promotion but instead may report as a special section to the director of distribution, also known as the sales manager The work of the director of distribution falls under several heads, each of which in large organizations is in charge of a competent executive Thus there is the

stance, either the manufacturing or sales division may have several departments The word 'division" is also used to represent a spatial or geographical unit of an organization

function of promotion, including advertising and the development of new markets, sales, and service after sales

The personnel or industrial relations division In a well-developed program the director of personnel (often called director of industrial relations) reports to a major executive, such as the president or executive vice-president or works manager His position should be on the same level as that of the factory manager [11] In a substantial number of cases, however, the director of personnel reports to the factory manager, since his division has quantitatively the largest amount of personnel work to do This arrangement may be satisfactory if all members of the organization understand the true function of the personnel department, but frequently it handicaps the work of the department From the standpoint of experience and qualifications the director of personnel in a medium-sized plant or larger should be in every respect as capable as the man in direct charge of manufacturing (See Fig 41 1 for an illustration of the organization of the personnel department of a large electric manufacturing organization) In its full development the personnel division has jurisdiction over all matters pertaining to the personnel of the organization, be that personnel in the comptroller's office, in the sales division, or in the manufacturing division

The manufacturing division Immediately under the director of manufacturing, or the "works manager," as he is frequently known, is the superintendent (Fig 5 5), who, with the aid of advisory committees, directly controls the operations of the foremen [12] of the various departments of the factory The foremen are directly over the workmen, possibly through job bosses, or assistant foremen, who may be in control of certain portions of their department There is direct line control or authority from the director of manufacturing to the workman It is the establishment of this responsibility and authority which promotes discipline and allows for the quick and accurate functioning of the organization [13] The manufacturing division affords the best opportunity to observe the effect of the functional

[11] See Holden, Fish, and Smith *Top-Management Organization and Control*, McGraw-Hill, New York 1951 pp 38 40 45–48

[12] The term 'foreman" is used rather loosely in industry One company uses the hierarchy of supervision as follows superintendent (of a division or branch) assistant superintendent, general foreman foreman assistant foreman section chief group chief (the lowest level of supervision) Another company of equal size calls its lowest level of supervision foreman" The general foreman in the first company occupies about the same position as the superintendent in the second company Other companies' terms such as 'supervisor and 'job master,' designate their foremen A foreman in one plant may be responsible for more men than a general superintendent in another plant

[13] Compare Fig 5 5 illustrating a complete organization, with Fig 5 7, the Buick Motor Division of General Motors

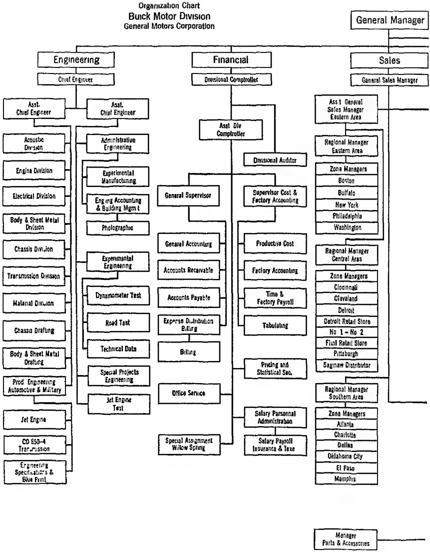
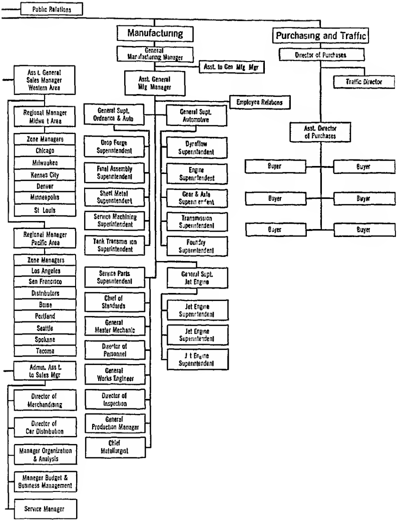


FIG 57 Organization chart of Buick Motor



Division, General Motors Corporation

idea in the development of the staff portion of the line-and-staff organization First, the purchasing agent is in charge of the purchasing department Under many of the older types of organization this position was ordinarily placed on an equal plane with that of the chief of manufacture In modern organizations the purchasing agent is sometimes found in the same position Making purchasing a main division of the business may result from consideration of the personal equation, but it is generally due to the importance of purchasing in the particular business Such correlation with other departments as is necessary can be secured through placing the purchasing agent on one or more advisory committees and still leaving him under the control of the manufacturing manager The value of placing the purchasing agent under the control of the director of manufacture lies in the correlation thereby secured of his functions with those of the production manager, inspector, and chief engineer The work of each of these men is bound up closely with the operations of the purchasing agent

The chief engineer is usually a member of the manufacturing advisory committee, and frequently he may be found on the plant advisory committee It is ordinarily a mistake to make the engineering or design department a separate division of the business, reporting directly to the general manager This arrangement tends to lay too much emphasis on changes of design of product, with the result that both sales and production departments are hampered in their operation However, there are some businesses, such as clothing manufacture and the automobile industry, where the designer is of great importance, and in such cases the chief design engineer may well head a separate division reporting directly to the president or general manager The chief engineer usually has charge of the design of the product, some or all of the equipment used in its manufacture, and related subjects

The production manager has charge of those features involved in aiding smooth flow of production [14] The chief inspector has charge of measuring and maintaining the quality of the product Under the superintendent in the factory organization are found the departments which deal with particular functions of plant operation The plant service manager has charge of the functions which primarily assist the other departments dealing with production to operate smoothly In some organizations the purchasing department, stores department, finished-stock department, shipping department, and transportation department report to the production manager

[14] The production manager in some organizations has charge of the standards and methods department the tool department the power department and the maintenance group To supervise these departments he must be an executive of high caliber, not just a clerical specialist The exact location of these departments depends largely upon their relative importance and personalities

(often called the manager of production control) This is a logical arrangement, since he is in the best position to issue orders to them On the other hand, in such instances he is responsible for the operation of a substantial number of workmen, and this function calls for qualities somewhat different from those needed for planning and scheduling, which are the primary activities in most production-control departments The planning department has complete jurisdiction over all the planning functions handled by the foremen under a strictly military organization, and in addition its development has caused the creation of certain new functions, as enumerated (Fig 5 5) The standards and methods department is interested in investigating and explaining how the work should be done, in order that the planning department may have a basis on which to plan, and the foreman on which to direct It also provides the inspectors with a basis on which to check the work The tool department insures that all tools of any kind that are necessary to production are ready at the time needed and in proper condition Thus maintenance of tools is part of the work of the tool department rather than the maintenance department

The power department has charge of the generation and transmission of power throughout the factory The maintenance department is responsible for the maintenance of plant, machinery, and equipment and is the logical outgrowth and development of the "repair boss" under the original scheme of functionalized shop supervision The inspection department under the chief inspector is the quality department of the manufacturing organization It is especially desirable to have different men working for quantity and quality At the same time their work must be correlated In industries in which the quality of the product is not of major importance, the inspection department may report to the superintendent The safety engineer has complete charge of all safety work in the factory His position is one of great importance As a matter of fact, in hazardous manufacturing he may become a man of such importance as to be called director of safety and to be one of the men immediately under the general manager

The plant service manager has charge of the stores department finished-stock department, traffic department, shipping department, and plant-transportation department In order to be able to control the planning elements of production, it is essential for the production manager to have close contact with the plant-service manager and the operation of the stores department The work of the other departments under the plant-service manager is self-explanatory, except that it will be noted that follow-up of purchases shipped and of finished goods shipped is often left with this group rather than with the purchasing and sales departments, respectively (See Fig 5 7, the Buick Motor Company, for another arrangement of these functions)

General Motors organization chart Figure 5 6 illustrates their corporate organization and the relationship of the various divisions to the central organization For many years one of the basic policies of the corporation has been ' decentralized responsibility with coordinated control " In studying this organization chart the student should keep in mind the fact that each of the "operating divisions" is a mass-production unit within itself and bigger by far than most large-scale industries Of necessity the organization of such an enterprise is more complex than that of a smaller business For instance, the Car and Truck Division has an executive vice-president of the entire corporation in charge Each of the main automobile companies has a general manager whose position, from the standpoint of the individual automobile plant is equivalent to that of the president of an independent plant (Fig 5 7) Few organizations indeed have taken the stockholders and the public more into their confidence than the General Motors Corporation, whose avowed policy is to make known in published form the principles and policies governing operation Figure 5 8 illustrates the top organization structure of another large company, the United States Rubber Company

Buick Motor Division organization chart The Buick Motor Division organization chart (Fig 5 7) should be analyzed in connection with the organization of the parent corporation For instance, in the parent organization under the executive vice-president there is a procurement and schedules unit, and the Buick Motor Division also has a purchasing agent The purchasing section of the parent organization buys certain items that may be purchased more advantageously by the central organization, and the Buick purchasing agent purchases items that can best be purchased direct The functions of both purchasing groups are large scale The chief engineer reports directly to the general manager, whereas the "general works engineer" and the 'general master mechanic" report to the assistant general manufacturing manager

Oliver Machinery Company Figure 5 9 illustrates the organizational structure of a closely held corporation whose major officers are also members of the board of directors of the corporation and its controlling stockholders Although the Oliver Machinery Company is corporate in structure, it actually functions very much as a partnership might function, each officer discharging the responsibilities for which he is best suited without regard to conventional relationships or individual factory departmentalization It works because of a high degree of cooperation between the officers of the company The president a graduate engineer, is works manager for all three plants and is in direct charge of Plant No 1, supervises costs for Plant No 1 and to some extent for Plant No 2, and together with other officers supervises designing The vice-president, also a graduate

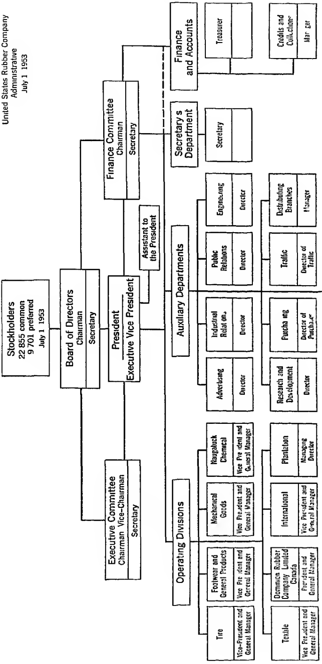


FIG 5 8 Organization chart of the United States Rubber Company

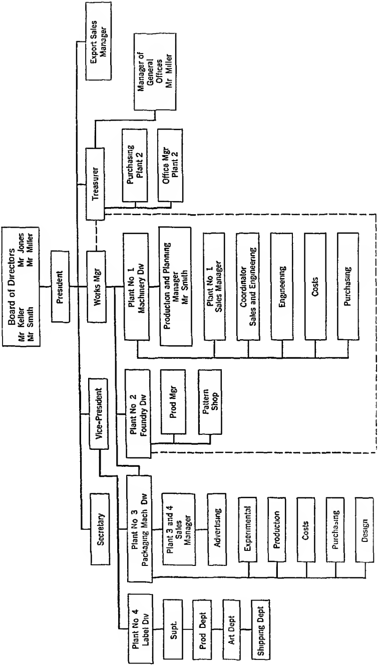


FIG 5 9 Organization chart of the Oliver Machinery Company

engineer, is manager of Plant No 3, supervises the production schedule and costs for Plant No 3, and supervises experimental work and designing, particularly for Plant No 3 The treasurer supervises financing, advertising, bookkeeping records, and purchasing for Plant No 2 He is office manager for Plant No 2 and supervises all accounting work for the entire organization Plant No 2 is a foundry in which all castings for the firm are made and also engages in jobbing work in heavy machinery castings and die casting for outside firms This plant is operated as if it were a separate organization The treasurer and the sales manager are comanagers for the general office which is located in Plant No 1 This organization, as has been stated, is built around the capacities of the respective major officers, president vice-president, secretary, treasurer, and sales manager It is conceivable that difficulty might be encountered in finding a man to take the place of any one of these officers, with the possible exception of the sales manager, should he suddenly be removed from active service by illness or death As it is now constituted, this corporation has successfully weathered the storms of the depression and the war years and it undoubtedly has the capacity to adjust its organization to the abilities of the men available when the present active officers retire Organization is not an end in itself but a means of achieving the end

Companies without organization charts An organization chart necessitates management's thinking through the structural relationships and the fixing of responsibility It also serves as a valuable aid in introducing new men to the organization The organization chart loses its value unless it is kept up to date Because they feel that organization charts restrict the scope of activities of executives to too great an extent, some companies refuse to use them The organization chart is merely a cross-sectional picture of the organization and may have to be changed often unless it merely gives the functional relationships and not the names of the persons discharging these functions In most cases, however, it is well worth the thought and effort expended upon it

6 ORGANIZATION, COORDINATION, AND MORALE

Coordination Figure 4.1 portrays coordination as the binding force tying together the various managerial functions of planning, organizing, and operating. Coordination may be defined as the synchronizing of effort from the standpoint of time and the sequence of execution. It is the common element in all managerial effort. The demands made upon management to secure effective coordination vary with the type of organization structure used, the degree of indoctrinization of the personnel in the organization's objectives, procedures, and policies, the caliber of the supervisory personnel, and to some extent upon the age of the operating organization unit, together with its traditions and customs. An old, well-established institution manned by persons who have been accustomed to working together for years will require less direction from top management to secure the desired coordination than will a new endeavor using the same organization structure but lacking personnel experienced in working as a team. An organization that has no well-integrated production-control department may do a fair job of getting out production but the time cycle for production will invariably be longer and the work in process will be larger. Many of the staff departments contribute materially to the coordination of effort. If each department head hires his own men (as was formerly the custom), one department may be laying off men at the same time that another department is hiring others with essentially the same qualifications. The industrial engineering department through the authority of ideas, facilitates coordination, particularly in terms of methods, procedures, and balance in equipment or personnel.

Morale Morale may vary all the way from the positive morale characterizing a group that has identified its interests with the objectives of the institution to the negative morale of the group that seriously questions the ability or willingness of the institution to consider the welfare or interests of its members. The morale may be high in regard to some aspects such as wages, and low in terms of feeling that the leadership is not impartial in matters of promotion. A morale-building organization tends to utilize fully the skill, initiative, judgment, and training of its members and succeeds in building up these and other qualities in everyone, so that the abili-

ties of all constantly expand, and the organization thus is able to succeed and grow All members of the organization are encouraged constantly to assume greater responsibilities at the same time having due regard for the rights of others Thus all executives become accustomed to think of the duties, responsibilities, and difficulties of their coworkers with the usual result of coordinate action and growth in capacity of the individual

The very elements which promote morale destruction, if applied in proper quantities, build morale Morale-destroying organizations are generally overorganized, although underorganization may also be morale-destroying In morale-destroying organizations restriction of the individual is the keynote The organizer has endeavored to impress his will on the daily actions and relationships of all members of the enterprise Into such organizations individuals enter filled with enthusiasm and a desire to make their tasks and themselves grow and, through them, the business It is not long, however, before they become aware of the restrictions that have been imposed, and before they learn that the energy they are utilizing in the performance of their tasks is not noticed or is not appreciated Although they endeavor to utilize some initiative in their daily operations, they find that they are hindered by lack of authority They try to temper their decisions with judgment, but they find that their decisions are not accepted or are restricted by supervising judgments "Followership" is as essential as leadership Organizations cannot be built through the executive's efforts alone Loyalty is one of the finest attributes of any member of an organization, but a management must deserve loyalty before it will receive it

Morale depressants Morale may be depressed by (1) too fine division of authority or responsibilities (2) too many supervisors, (3) improper selection of personnel for new or expanded duties, (4) overreliance on organization charts, and (5) too few real executives Any of these conditions is likely to arise in the course of building an organization

Division of authority The division of authority and responsibility should not be carried to a point that will preclude original thinking by subexecutives This does not mean necessarily that responsibilities may not be divided finely, nor that those entrusted with responsibilities may not receive the expert advice of others in particular phases of the work It means that considerable initiative on the particular line in which he is engaged must be left to each executive in order that he may take pride in the accomplishment of some definite phase of the work, however small Effective leadership is half of an executive's job It cannot be expected to flourish where individual growth has been prevented Good executives will not tolerate such restrictions and will seek other connections Poor executives constantly become poorer, as they rely always on instructions from above The final result is that confidence in the business is lost by those

on whom its success largely depends, the subexecutives in direct charge of operations

Too many supervisors Taylor's functional supervisors encountered resistance because there were too many of them giving orders to each worker Many of the more able executives, who grasped the advantages of specialization of effort and were willing to adjust their organizations to use the new techniques, early pointed out the fact that there is very definite danger of allowing functions to be created merely because they seem to be different, and without an adequate check being provided to see that they are or can be made to be paying investments There is a very real risk of developing a situation where "for everyone doing productive work there is another man standing over him to see that he does it" Balance is needed in determining the number of supervisors required, as well as the number of workers to turn out a given volume of production Too few supervisors may be as much of a deterrent to group morale as too many A well-trained group requires less supervision than beginners

Improper placement While seniority rights have been recognized for centuries and have a deep-seated appeal to sentiment, seniority should not be the sole basis of promotion If it is seen that length of service clearly outweighs value of service in reassigning duties or filling vacancies, the direct effect will be a let-down of effort, especially by subexecutives The deadening effect of the application of the seniority rule can be found in the listlessness displayed by subexecutives and clerks in the offices of certain large railroad companies which base their promotion or organization-development policy solely on seniority Thus it is clear that the manager, in building organizations, must consider his new or expanded duties in the light of two almost opposite reactions of his personnel the aversion to the newcomer and the necessity for—but, at the same time, the impossibility of—following the seniority principle The effective organization is the one in which the tortuous channel around and between these conditions has been traveled with success Another phase of placement is important If too many persons of superior ability are placed in a given department they soon discover that their opportunities are limited Jealousies and discontent are certain to follow Management should constantly strive to keep the *interests* and *capacities* of its employees balanced against their *opportunities*

The formal organization chart The formal organization is a necessary tool of management, yet every organization specialist realizes the importance of the informal relationships within the formal structure Leadership frequently is made effective through some person rather far down in the organization scale Divisions or departments of the business may be built around the personal qualities and problem-solving abilities of this

person If the organization chart is looked upon as more than a guide, this man's ability to lead and coordinate actually may be throttled The free-lance assistant to the general manager, who can eliminate much friction before it gets started, has duties which it is most difficult to portray satisfactorily on a chart The objections and inherent defects of formal organization charts do not indicate that the charts should be eliminated Charts frequently may be made more workable if supplemented by standard-practice instructions, but of themselves charts can never be regulations for organization operations

A shortage of real executives Organizations, like other structures, must be built to survive the maximum strain which may be placed upon them In the ability and action of the executives throughout the organization lies the factor of safety If provision has not been made for this factor of safety, the structure may collapse under the strain of unusual pressure The executive who is a slave to system seldom provides the dynamic leadership needed for a positive morale The overworked executive who does not have the time to use the human touch also stifles the normal growth of the "will-to-do" that is characteristic of the organization that knows where it is going and how to get there

Characteristics of a morale-building organization A continuing positive state of mind is only found where the environment encourages confidence, a feeling of security, and an awareness of succeeding An organization that builds morale is one that follows carefully the *primary fundamentals* of organization and has carefully developed the *operating fundamentals* of organization to implement them To acquaint the personnel of an enterprise with its aims and objectives is a function of leadership It is largely achieved through training Development of responsibility within the definite lines of supervision requires first the laying down of such policies of supervision (a top-planning assignment) and then proper delegation of responsibility (a leadership assignment) Regard for the personal equation is primarily an attitude arising from the individual's social background It is an outgrowth of his respect for the dignity of the individual The mere fact that a person desires recognition himself does not imply that he will grant it to others below him Attitudes toward the recognition of the personal equation are formulated over a long period of time Similarly, a long time is required to change them Group conferences in which the chief executive sets forth the company's policies regarding men are helpful, but the day-to-day examples of the superior executives are more influential than theoretical discussions

A morale-building organization has a technically qualified work force including supervisors as well as manual workers that possess confidence in their ability to achieve the institution's goals A group of this type can be

assembled only through careful selection and purposeful training Many executives who are not organization minded underestimate the effect of proper organization structure They assume that the capable man will rise to the top in any event Such is far from the case A capable man who respects the rights of others may readily be passed by an unscrupulous climber with less ability than the man who will not stoop to intrigue Personal integrity on the part of the executive force, coupled with dynamic, inspirational leadership and a properly balanced organization structure, constitutes an ideal seldom completely realized but one worth constant effort to attain Under such circumstances morale is certain to be high, discipline will be positive rather than negative, and the institution will move slowly but resolutely toward its goal

Successful organizations are usually the result of slow, painstaking adjustments and growth Custom and tradition are powerful factors not to be ignored in dealing with human relationships An organization structure has to be adjusted to the capacities of the available personnel A particular organization setup may well be a success if installed gradually, permitting persons to make needed adjustments without undue emotional strains, whereas the same organization will result in dismal failure if inaugurated too rapidly, particularly if forced from the top Time for seasoning is as necessary in securing a smooth organization structure as in many other relationships

Functional definition Delegation is the process of multiplying the leadership of an executive To be truly effective delegation must be accompanied with a clear definition of the functions to be performed [1] A recognition of responsibility, with full knowledge on the part of the recipient that he has concurrent authority, is a strong motivating force It results in a high type of morale when authority and responsibility are properly balanced and generally recognized throughout the organization This principle of fixed responsibility should extend down to the individual workers The typical workman likes to feel that he has a responsibility in keeping with the work he does When an individual worker, subexecutive, or executive undertakes to discharge the clearly defined responsibilities that are his, he usually develops a keen organization sense for the rights and duties of others This recognition of interdependence within the organization fosters a spirit of cooperation, which characterizes a group possessing a high degree of morale A lack of definite responsibilitity and authority to meet this responsibility results in hesitancy and uncertainty, develops friction, reduces the needed coordination and depresses morale

[1] See *The Principles of Organization*, James D Mooney and Alan C Reiley Harper, New York, 1947, p 23, for an excellent discussion of this important subject

If the organization has attained sufficient age to have undergone a thorough indoctrination with well-developed company policies, many of the procedures are automatically carried out as a matter of tradition or custom Fixed responsibilities within an organization tend to develop men who are capable of assuming the burdens of these responsibilities and willing to do so Such men are capable of meeting unusual situations and emergencies In such an organization the full utilization of the sound principle *that decisions should be made at the lowest level within the organization where the facts are available and competence exists to decide* is encouraged

Adequate supervisory force The ideal situation is a matter of delicate balance between too few and too many supervisors The type of organization determines to a considerable extent the exact number of supervisors required The nature of the enterprise is also a determining factor An organization manufacturing a standard product on a mass-production basis will require a relatively smaller number of supervisors than one manufacturing a variety of unstandardized products

The most effective way to insure prompt adjustment of grievances, with resultant morale-building effects, is to have adequate supervisors well trained in the principles and practices of the company Unadjusted grievances tend to be magnified in a geometric ratio to the time elapsing Although this rule does not hold with mathematical exactness, it is nevertheless generally true

Even in organizations having a strong central planning department, there still remain much analysis and planning for the individual supervisors In general, these functions will be carried out thoroughly and competently only when daily tasks are not so pressing that they leave no time for anything else It takes time to plan for the organization as a whole, and it also takes time for the individual to plan and analyze his work This is just as true of functional supervisors as of general supervisors Effective functionalization within an organization encourages morale building This principle can be carried out only where adequate supervisory personnel is available Skilled men in a given function bring to their work an assurance that provides the positive attitude so necessary to good morale within a group

Selection, placement, and promotion The personnel department is an outgrowth of Taylor's functional foreman who was in charge of *discipline* The present-day personnel manager has come a long distance from Taylor's "disciplinarian" He participates actively in the selection, placement, and promotion of the employees Men who are well equipped by natural abilities and acquired skills to do a given task will usually find satisfaction in its performance A group of men who get personal satisfaction out of their work will usually be a happy group A carefully organized *promotion*

policy does much to encourage organization pride and morale A thorough-going promotional program requires long-range planning It pays well in the long run, but it also involves costs in the short run It is seldom that a man is found within an organization who fits the exact requirements of a position offering promotional possibilities, particularly if this position is a newly created one, unless a definite program has been in operation to prepare men for promotion The easy method is to go outside to find a man for the opening Such a procedure tends to discourage the men within the organization who are ambitious to advance This does not mean that men should never be brought in from the outside A new viewpoint is frequently stimulating An occasional new man will also serve as notice to men within the organization that they must qualify if they expect to be promoted

During prolonged periods of depression some companies have retired some of their senior executives with unusually favorable pension arrangements to make room for promising younger executives, thus making possible a series of chain promotions which relieved considerably the pressure all the way along the line with a very salutary effect on morale Sometimes a far-sighted management promotes men to better jobs in another outside organization Management learns of openings for them in other organizations Worthy men who have no prospects of promotion within the organization in a reasonable length of time are told of these outside opportunities and aided in making necessary contacts Such a movement on the part of management soon becomes generally known and the feeling that merit is rewarded promotes company morale

Leadership and morale Leadership is the direction of the efforts of people toward a desired objective or goal The quality of leadership definitely influences the "will-to-do" of the group Coordination is the direct responsibility of the line executive Men like to be led by a strong leader Dynamic leadership is particularly important to subexecutives who come in direct contact with the working force as a whole The purely intellectual leader may succeed at the top if he selects wisely the lieutenants who represent him The dynamic leader has confidence in himself and the capacity to inspire confidence in others He knows what he wants and goes after it He has a definite program for himself and his organization He knows his own job and expects his subordinates to know theirs He willingly delegates responsibility and authority and is exacting in demanding performance He possesses vision and a constructive imagination Such a leader is loyal to his associates and commands loyalty in return Unfortunately many leaders possessing dynamic characteristics temperamentally dislike details The organization specialist is constantly faced with the problem of compromise in selecting his personnel Special selection and training

are valuable aids in building an organization manned by strong personalities that are accustomed to giving adequate attention to necessary details

Responsibility and authority Figure 4 1 shows that responsibility is the central core of the executive process Authority emerges as the necessary corollary to responsibility When the group recognizes that the authority arises from responsibility it is usually accepted as meeting the requirements of the "law of the situation "[2] The allocation of authority is primarily a responsibility of top management, functioning through the organization structure In order to see that authority is properly used, top management must have checks other than those provided solely by the line The personnel department, the industrial engineering department, the inspection department, and the accounting department provide some of these checks

Followership is as important in leadership as leadership In fact the two go hand in hand Followership is encouraged when the organizational structure creates an atmosphere in which responsibility is recognized and the objective has been made known to all parties to the process Authority is a right that inheres in an individual, department, or organization to decide and to 'command' when commanding becomes necessary to discharge the responsibility To command does not imply to order without regard to the rights and dignity of the recipient of the order A request made by a person in a position of authority and responsibility is the customary method of giving orders In military drill and during an emergency, of course, a direct command may be used The time and circumstance greatly influence the exact method to be employed

Consultation Consultative supervision implies that those supervised are asked to give their opinions regarding the best method of getting a particular task done Such a procedure brings collective concentration and effort to bear upon a given solution rather than the ability and thought of one person It definitely raises morale and is an excellent technique for getting things done The foreman who practices consultative supervision

[2] See Ralph Currier Davis *The Fundamentals of Top Management*, Harper, New York 1951 pp 151–152 for an excellent discussion of the "Law of the Situation" Stated simply the *law of the situation* declares that the solution to business problems depends in a large measure upon the executive's ability to determine the facts, his courage to face them and his ability and willingness to follow the course of action they dictate Some students of leadership have said that a good executive must be 'tough minded In this sense he is required to do things that he may not want to do but that are required of him to serve the best interest of the organization He may have to make difficult choices involving persons whom he really likes Managerial decisions should be motivated by the major organizational interests, not personal friendships

will find that detailed follow-up is not so necessary as when orders alone are used

Balance has to be kept in mind in practicing consultative supervision It is not the fact that the subordinates have been specifically asked in a given situation that really counts so much as it is that the particular leader has built up a reputation for desiring to have the collective thought of his associates Too many conferences and committee meetings keep the responsible leaders away from their duties, require overtime to get the needed duties performed, and depress morale Too few conferences may be even more wasteful of time The most important phase of morale building through consultative supervision is the getting of every supervisor from the highest to the lowest to practice it All too often the foreman wants to be "in on the know" but fails to take his own men into his confidence Real "consultative supervision" is an attitude of mind that is manifest as a continuing desire to recognize the rights of others

In practicing consultative supervision the responsible executive is alert to the informal organization in his group Frequently two or three of his men have acquired an informal recognition by their associates At times these informal leaders may be consulted instead of the entire group

7 PRODUCT DEVELOPMENT AND RESEARCH

Historical background of product development In view of the phenomenal developments during the present century, we are prone to underestimate the achievements of the past When viewed from the standpoint of the knowledge available and the tools at their command we must have profound respect for accomplishments of the ancients Before the discovery of America the natives of Guatemala were using fast vegetable dyes The early Egyptians processed copper in a manner which has been claimed to defy duplication even today Early histories of China report the use of gunpowder Five thousand years ago the Mongolians were using tea leaves to treat burn trauma, in 1925 the Henry Ford Hospital of Detroit announced the modern counterpart of this remedy, the tannic acid treatment for burns Modern scientists are striving to unlock the secrets of the past

Many of the materials of nature are not so satisfactory as man would have them be, they are heavy when he would prefer them light, soft when he wants them hard, and solid when they should be liquid The more exact scientific methods of the nineteenth century freed man from many of these handicaps Schoenbein nitrated cotton and obtained nitrocellulose, which Hyatt discovered how to plasticize into a pliable product DuChardonnet completed this nitrocellulose cycle by spinning the first filament [1] Despite the fact that we think of rayon as a modern product its early beginnings appeared in the middle of the last century Today American chemical research in rubber and synthetic fabrics ranks second to none in the world, as does our medical research World War II produced synthetic rubber on a commercial scale and unlocked the secret of atomic energy We have long led the field in mechanical research and development

Kinds of research Research may be defined as *the search after new information by the scientific or experimental method* Pure research seeks

[1] Much of the material in this paragraph is adapted from a speech delivered by Paul F Ziegler, research director of Bauer and Black Chicago Illinois before the Chicago chapter of the Society for the Advancement of Management

truth for its own sake without regard to its utility, whereas applied research seeks to solve specific problems with consumer utility as a direct incentive Some authors have used the terms "extensive" or "fundamental" research to refer to pure research and "intensive" research to denote the effort to solve specific industrial problems Intensive research strives to enlarge our knowledge about existing things or things that might well be, so as to enable us to improve them or reduce their cost, or both, as well as to create a new utility or service Extensive research seeks to extend the frontiers of knowledge for its own sake Both types of research have a place in our social and economic structure, and neither can truthfully claim any superiority over the other Industry and commerce are primarily interested in research in the economic and social sciences and in materials, equipment and processes Industry is primarily engaged in intensive research, extensive fundamental research, however, serves as a stimulus to more effective intensive research Some industries do engage in basic research, however, universities and colleges lead in this field

The need for industrial research Regardless of how smoothly an industry may be operating at a given time, new problems arise that require research to overcome In a competitive economy new products or improvements in an old product become a necessity to keep abreast of the parade Most companies grow slowly and enter research as a part of that growth This statement, of course, would not be true of a new undertaking sponsored by a large organization, such as the General Motors Corporation or E I du Pont de Nemours & Company, Inc , which has at times conducted exhaustive researches in its main laboratories and then built complete plants with the last word in technical equipment to exploit the findings of its researches Most industrial research arises from an attempt to solve two different situations or needs, namely, (1) the need to solve problems arising in connection with current operations, and (2) the need to devise new products, to improve the present product, or to find new uses for the present product or a new one

Economic considerations in industrial research Industrial research is conducted for the purpose of promoting the primary objective of the business This objective may be in the area of selling, personnel relations, manufacturing processes, or product design While industry does engage in some pure research, most of its efforts are directed to overcoming present problems or improving the present processes or products In other words, industry is keenly conscious of costs

Economic considerations Before deciding to undertake a research project or to exploit the results of research already accomplished, it is necessary to analyze the economic implications Investment in machinery and equipment must be gauged by the immediate savings which will be

made, by the necessity of reducing production costs to meet competition by the likelihood of new processes being developed to replace the equipment whose purchase is being contemplated, by the life of the equipment by the condition and manufacturing possibilities of the equipment already owned or competitive equipment which may be purchased, and by the prospective length of life of the design of product on which the contemplated new equipment will be used

Business undoubtedly needs research as much during depression periods as at any other time but during these periods the owner knows that he must maintain his balance sheet in a liquid condition, and that he must scrape along with the old-style machine or the old-style process a little longer, no matter how dissatisfied with it he may be Large aggregations of capital secure their greatest relative advantages in periods of depression Enterprises in a strong financial position do not lay off their research workers and do not stop process development, they keep at work, bide their time, and, when conditions improve, produce commodities that are demanded by the consumer Their competitors then attempt to follow, and those who are unable to do so because of financial or patent reasons are soon out of the race

Product design and conflicting interests The manufacturing department strives toward standardization in design and relatively few models The design engineer who can devise means of creating diverse-appearing products from standard materials and processes is usually the leader in his field The managerial factors which exert an influence toward standardization include

1 Lower investment in plant equipment materials and finished inventory
2 Resultant price reductions so that the market for the product is enlarged
3 Interchangeability of parts if product is mechanical
4 Possibility of development of automatic equipment or standardized chemical or mechanical controls

In order to appeal to the many tastes and interests of the customer the sales department strives for diversity The factors encouraging diversity include

1 The necessity of meeting the needs, desires and purchasing capacities of various consumers
2 The gain in sales appeal through product changes, so that the merchandise appears to be up to date
3 The need to meet price competition by changing construction of the product in minor details so that the price may be slightly reduced
4 The necessity of meeting several competitors products of varying design or varying materials
5 The limitations imposed by process or design patents of the particular company or its competitors

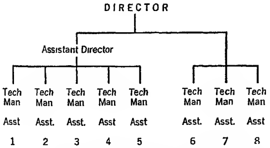
6 The desirability of developing several competing but dissimilar lines to enlarge the number of retail outlets

7 The continued development of technical processes and equipment and adjustments to take advantage of the possibilities of these developments

Organization for product design and research Active participation in production routine is not conducive to research It will often be neglected entirely unless a particular executive has a special personal liking for it, in which case production not infrequently suffers from lack of attention Specialization gives large returns in the field of design and research The essential factors that foster research and product development are time to pursue the investigations, an inquiring state of mind supported by sufficient effective training or experience in systematic investigation, and the facilities necessary to carry on the research The mistake is often made of laying the major emphasis on buildings and equipment, but in reality the buildings and equipment may be meager for most research, provided that the state of mind is right and time is available to pursue the inquiries

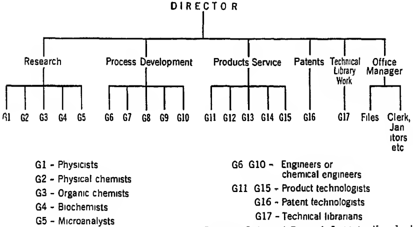
In many of the larger enterprises the product engineer is a vice-president on an equal status with the sales manager and the factory manager The research division may be a section of product engineering, product engineering may be a division of research, or the two may be entirely separated Where the two are joined in the same organization there is more likelihood of a closer tie-in with actual production problems If research is really to function, it must be allowed to work on its primary objective and not have its efforts expended on tasks that belong to the producing departments or inspection It is always a temptation, particularly in highly technical processes, to call upon the research or development department when production encounters difficulty Regardless of the position in the organizational structure of the product engineer, if he is to be effective he must work closely with the production, purchasing, and sales departments

Figures 7 1 and 7 2 illustrate the organizational structure of research departments, depending upon the number of men in each In Fig 7 1 the department is composed of 10 technical men Groups 6, 7, and 8 are primarily concerned with products service and report to the director, since he is presumed to have a primary interest in the quality of the products Groups 1 to 5, working under the assistant director, will handle both process development and pure research, with primary emphasis on process development Patents in such an organization are usually handled by the director in consultation with outside attorneys Figure 7 2 illustrates an organization having 100 technical men, hence the higher degree of specialization In a research organization there is frequently a nontechnical helper or other clerical aid for each technical person It is a gross waste of the



Courtesy Industrial Research Institute New York

FIG 7 1 Organization of a research department having 10 technical men



Courtesy Industrial Research Institute New York

FIG 7 2 Organization of a research department having 100 technical men

technical man's time to have him doing tasks for which a helper or clerk is suited

The need for harmonizing conflicting interests Management is charged with the determination of objective and the coordination of effort to achieve this objective In relation to product design and research, management must consider the following

1 The desire of the consumer for utility, quality style and color within a given price range must never be ignored

2 The cost of product development must be kept within the capacity of the business enterprise to pay

3 Due regard must be given to the effect of introducing the new product upon the rest of the company s products, both from a selling and a manufacturing point of view

4 There is need for coordinating the various departments interested in design, such as the methods department, the manufacturing division, the purchasing department, the sales department, and last but not least the finance division

The consumer In most competitive situations the consumer is free to buy what and where he desires In the final analysis the consumer decides what products he wants Since production is largely in anticipation of demand, it is necessary to anticipate the consumers' desires in marketing a new product or an improved one The consumer wants not only style and color but also utility A vital factor from the standpoint of consumer utility is ease of maintenance The product engineer should strive for accessibility for maintenance and keep in mind that the product will be repaired in the field where facilities are not the same as in the producing plant Low maintenance cost provides a strong selling point

Some enterprises have sought to find out from the consumers themselves what they want in a product These companies conduct exhaustive consumer research Other companies employ outside counsel in determining consumer preferences There are special market-research corporations that will undertake a consumer study for a fee They may use a questionnaire or send out interviewers to question a representative sample of customers

Controlling research and development costs The sound procedure is to budget developmental and research costs and to keep an accurate record of all expenditures for each project Such a program will tend to keep costs in a balanced relationship to each other and to prevent all available funds from being spent for one purpose when other problems also demand attention Monthly or periodic reports should be rendered on the expenditures to date on each research project, accompanied by a progress report It is seldom possible to predict the cost of a research project with the same accuracy that manufacturing costs are made, but this fact does not mean that research costs should not be budgeted

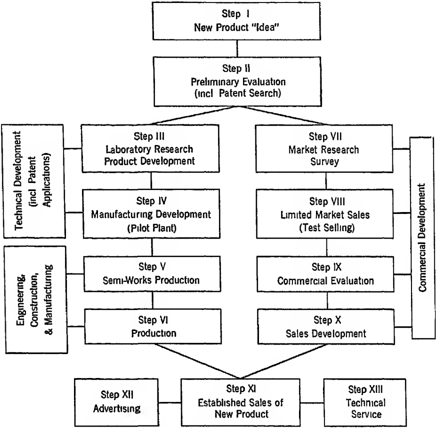
What percentage of profits or of sales should be spent in research? The answer is sometimes estimated to be 10 per cent of profits or 2 per cent of sales Naturally such estimates are in no sense final When a particular company is faced with a number of problems needing solution, the budget for research may readily be in excess of the estimated 2 per cent of sales, provided of course that the financial situation is such that funds are available Research is both an insurance against unexpected developments and a speculation in possibilities of future business It is difficult to predict where the insurance aspects cease and speculation begins [2]

[2] See Industrial Research Institute, *Organization of Technical Research in Industry* (a monograph), New York, 1945, p 5

Coordinating departmental interests in product design The research man and the product-design engineer tend to concentrate on the product and neglect the problems raised in its manufacture and servicing It is common practice for the methods engineer to suggest modifications to simplify production The purchasing department may find it difficult or unnecessarily expensive to get certain specified material or parts The logical method of resolving the various conflicts of interest is to have all interested divisions a party to the final decision The design engineer may well consult the methods department and the manufacturing division as he progresses Such coordination may easily result in modifications of design that do not interfere with the basic operation of the product and yet make possible the use of present equipment, thus avoiding unnecessary expenditures for new equipment or later changes in design By working closely with the sales department, the design engineer will have the benefit of practical customer reaction as well as the enthusiastic support of the sales group in marketing a product for the design of which they feel some responsibility The purchasing department may render valuable suggestions regarding economies in buying certain materials or parts that may be specified especially in terms of standards and dimensions that are used in the trade

Procedures in research and product design The design of a new automobile is a good illustration of the details involved in a large-scale development program (Fig 7 3) The management may decide that it desires to produce a car that will sell in the $1300 class This, then, will become the first controlling factor There being a fair relationship between selling price and weight of a car, the approximate over-all weight may be settled in advance The next decision may well be wheel base, concerning which the sales department may agree merelv to meet current competition, in this event the over-all dimensions are already established by the trade Since there are many specialized parts in an automobile, the chief product engineer would then assign to each special group its task and give each group approximate requirements concerning weight for each unit and cost limits Some of these special units are the frame, lubrication of chassis, the engine proper with a subdivision of ignition, clutch, and transmission, spring suspension, wheels and tires, and body Each of these major heads may have several subdivisions, the body, for example, will have at least body contour, paint, trim or upholstering, and body hardware Since practically all cars give satisfactory performance, the actual mechanical working parts are fairly well standardized, and established practice may be followed with minor improvements that may reduce costs or increase efficiency The general appearance of the car will greatly influence its popularity with the buying public, hence, the design of the body proper, cowl-

ing, and radiator must receive special attention for style appeal A specialist may work on the rear, another on the side view, another on the windshield, another on the hood and cowling, and still another on the radiator The composite efforts of these specialists may then be put to-



Courtesy American Management Association General Management Series No 166 1953 p 16

FIG 7 3 Steps in converting a new product idea into a new business

gether into one drawing to give the general picture of the projected product, which may have to be modified if the various parts do not harmonize (Figs 7 4 and 7 5) Another approach is to have an artist sketch the completed design, make changes until it meets the approval of the major executives, and then assign to each specialist his segment of work to harmonize with the artist's approved design A temporary wooden or plastic model will then be made, painted, and possibly upholstered to serve as a complete model This may be changed until it receives final approval,

the dimensions of the approved model are then transferred to an aluminum sheet to avoid distortion arising from temperature changes in the room From this metal sheet, body dies will be built and actual production will

Courtesy General Motors Corporation

FIG 7 4 Step 1 Full size preliminary blackboard drawing of a proposed body design

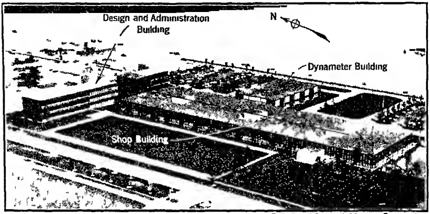
Courtesy General Motors Corporation

FIG 7 5 Step 5 Full size plaster model for appearance check from molds from clay model which is step 4

later be run Any major mechanical changes that have not been previously tested on the road will receive exhaustive road tests before the new car is marketed

In modern industry research tends to be a cooperative matter rather than the work of one person On receiving a request for research or upon

conceiving a project, the first step might be called a "library exploration" to find out what has already been accomplished in the field This exploration, which includes a search of the company's own files and any published data in the field, is followed by outlining the procedure in the light of the information discovered In a large or small development or research project at least two types of procedures may be used One is to assign the entire project to one man to follow through He is free to call upon other specialists for help and advice wherever needed The other is for



Courtesy General Motors Corporation

FIG 7 6 Engineering staff building of General Motors Technical Center

the director or a committee to retain active control over the project and to assign segments of it to specialists, each specialist working on his phase of the work, sometimes without a full appreciation of the major objective of the entire effort In either case there may be departmental meetings from time to time to discuss the respective projects and thus acquaint the various persons with the work of the others and to get the collective thinking of the group focused upon a given project

The director of a research staff must be able to recognize questions needing answers and problems awaiting solution and have the capacity to select the most urgent ones at a given time and to delegate each problem or parts thereof to the person best equipped to handle it With the increase in the number of persons actively engaged in research in many industrial enterprises has come the necessity for established procedures and the delegation of responsibilities The director of a large research department must combine an inquiring mind and technical training with high executive ability A large central research unit, such as the one operated by General Motors (Fig 7 6), conducts three different types of activities

for the corporation as a whole and the respective operating divisions (1) pure or applied research initiated by the research unit, (2) "library research" for the respective divisions, since the central research units have a comprehensive library and records of most of the research of the other divisions, and (3) special research activities that any of the operating units thinks can be more effectively pursued by the central staff than by the division research staff

Services of the product-design and research departments to other departments Manufacturing, sales, and top management often turn to the research or design department for help

1 *Top management* Management relies upon its research and design departments to detect incipient changes that become indicated by the discovery of new facts and new intermediates, either within or without the given enterprise or industry, because it is within the realm of possibility today for a business to be ruined overnight by such scientific discoveries The multitude of scientific discoveries that are emanating from the many university, industrial, and public laboratories challenge research ingenuity to evaluate them in terms of the organization's products The newer scientific equipment also falls within this field, as is evident in the adaptation of the principles of radio to the determination of noises in automobile transmissions and the use of X-rays in detecting defective castings Whenever scientific meetings are held, reports indicate latent possibilities of new industrial products or processes It usually requires the applied research worker to detect new-product possibilities in these embryonic stages

2 *Manufacturing* The research group is frequently called in to help solve manufacturing difficulties arising in a highly technical process This is a reasonable request but it should not be done frequently or the basic objectives of the research department will suffer If technical difficulties occur often a special technical staff should be established to take care of them A second contribution of the research department to the manufacturing division is intensive investigation for the improvement of processes This function in no way replaces the work of the mechanical department charged with methods improvements but rather supplements their efforts, particularly in those phases of the process involving chemistry and physics

Although the actual patent litigation is handled by the legal staff much of the original data used by the legal division must be provided by someone else Research and product design result in patents The laying of a firm foundation for a patent policy goes all the way back to the laboratory notebooks and the records of the product-design department, where intelligent and adequate notations should be made and samples and models developed and carefully filed away The writing of patent specifications is a cooperative task between the research or product-design representative

and the patent attorney In subsequent litigation the success of the firm often depends upon adequate records which were properly kept and dated during the period of development and research

3 *Sales* The product-design and research divisions must keep the products which the sales department is selling at the top of the list of competing products within the given price range The research laboratories are constantly making complete detailed chemical and structural analyses of competitors' products A sales department has a right to expect from its product-research and design divisions a reasonably constant flow of new products within the field of their operation A reservoir of possibilities should be available for addition to the line as they may be needed These possibilities should be well beyond the laboratory stage and should have had some initial field tests, which may be conducted under the direction of the research and design departments Conversely, it is the responsibility of these departments to filter out from sales consideration allegedly new and useful products which have no scientific merit

Occasionally the research or design divisions interpret technical data and results so that they may be used to the best advantage by the sales department Such technical helps increase materially the effectiveness of sales effort The advertising function can be more intelligently carried out by a close tie-in with a sympathetic scientific group If the sales department requires very much of this type of aid, a special technical aid should be employed to render it rather than disturb the normal work of the research group

8 SIMPLIFICATION AND STANDARDIZATION OF PRODUCTS AND MATERIALS

Definitions *Simplification refers to the elimination of superfluous varieties, sizes, dimensions, etc* It is essentially a reducing process, a cutting down of varieties and types with relatively little regard for the use of scientific procedures or methods It may well be described as an empirical process On the other hand, *standardization refers to the setting up of fixed sizes, types, qualities, measures, etc Standardization implies careful consideration of relationships and values usually involving scientific procedures* Standardization generally involves a reduction in the number of sizes and types, however, it frequently requires the establishing of new sizes or types to take the place of some of those eliminated Standardization is primarily an engineering function which has a direct influence upon commercial usage and practice Simplification is the selection of those items that are in greatest demand and the elimination of the others in so far as production for stock is concerned It is essentially commercial and not technical Although the foregoing distinctions are stressed among certain students of production for the purpose of clarity in use, it must be conceded that others with considerable logic use the terms interchangeably Professor Kimball defines simplification as "standardization in a limited number of particulars " [1]

Standardization is the process of establishing standards A *standard is a carefully established norm, measure, or specification, covering a method, material, product, procedure, or any other phase of a business process* The standard is merely the best method, condition, or specification that can be devised at the time, taking into account all the limiting factors, such as price range, available equipment, and materials used Improvements in standards are usually desired and adopted whenever they are found Although nothing in the idea of standardization precludes change, standardization tends to stabilize, thus preventing modifications other than improvements

[1] See Dexter S Kimball and Dexter S Kimball, Jr, *Principles of Industrial Organization*, McGraw-Hill, New York, 1947, pp 303–304

Management's needs for standards Viewed from the broad managerial approach, standards are of value to management as follows

1 They create a foundation upon which other steps of good management may be built

2 Establishing standards causes a careful investigation to be made into all phases of the business Without such investigation standards cannot be intelligently set

3 They tend to aid routine operation of the business and thus the development of a system and the application of the exception principle of management

4 They reduce costs of operation in a way peculiar to themselves, thus making possible reduced costs to the ultimate consumer as well as increasing the profits of the business

Frederick W Taylor said

It was in the course of making a series of experiments with various airhardening tool steels with a view to adopting a standard for the Bethlehem works, that Mr J Maunsel White, together with the writer, discovered the Taylor-White process of treating tool steel, which marks a distinct improvement in the art The fact that this improvement was made not by the manufacturers of tool steel but in the course of the adoption of standards shows both the necessity and fruitfulness of methodical and careful investigation in the choice of much neglected details The economy to be gained through the adoption of uniform standards is hardly realized at all by the managers of this country [2]

When manufacturers, distributors, and users adhere to the voluntarily developed Simplified Practice Recommendations, the following advantages accrue [3]

To the Manufacturer

1 Less capital tied up in slow-moving stocks

2 More economical manufacture due to less complicated inspection requirements, longer runs with fewer machine changes, less idle equipment, less stock to handle, etc

3 Continuity of employment as contrasted with seasonal employment

4 Larger units of production and less special machinery

5 More prompt delivery

6 Less chance of error in shipment

7 Less obsolete materials and machinery

To the Jobber, Wholesaler, and Retailer

1 Increased turnover

2 Elimination of slow-moving stock

3 Staple line, easy to buy quick to sell

4 Greater concentration of sales efforts on fewer items

5 Decreased capital invested in stocks and repair parts on hand

6 Less storage space required

7 Decreased overhead and handling charges

[2] Frederick W Taylor, *Shop Management*, Harper, New York, 1911, p 124

[3] Edwin W Ely Chief Commodity Standards Division Office of Industry and Commerce Department of Commerce, Washington 25, D C

To the Consumer

1 Better values than otherwise possible
2 Better service in delivery and repairs
3 Better quality of product

Advantages of simplification The benefits accruing from simplification of the product include lower unit cost, decrease in capital invested, lower labor cost, advance in the technique of production, improvement in equipment utilization and control, possibility of speedy and reliable delivery, improved quality of product arising from concentration of effort, and increased turnover of capital invested in inventories Together these insure consumer satisfaction because of prompt service at low prices, in addition to greater profits on the same investment for the manufacturer A decrease in the capital investment is brought about through the utilization of less machinery and fewer tools, patterns, and other auxiliaries, as well as through the reduction in the inventories of raw material, parts, or partly worked material and finished stock Lower labor costs come with familiarity of the workers with their more frequently repeated tasks, as well as with the steadiness of employment that follows the well-defined production programs that can be mapped out when the product is standardized Increased stabilization of employment is one of the major benefits that will result from further simplification

Simplification also results in production with less wastage of material Knowledge of the organization becomes specialized along narrower lines, and thus there is a tendency toward constant improvement of process Not only can equipment especially suited to the product be procured, but also each type of equipment can be more easily assigned to the production of that portion of the product to which it is best suited Product standardization has all the advantages which have been claimed for simplification but to even a greater degree, both within the producing and selling organizations and in the broader socio-economic relationships of the customers

Table 8 1, provided by Mr Edwin W Ely, Chief of the Commodity Standards Division of the U S Department of Commerce, gives some of the savings that have come about through the application of simplified practices

Production economics from simplification Figure 8 1 shows a Fourdrinier machine used in making paper The American Writing Paper Company using a machine of this general type reduced their line from 2000 separate varieties of paper to approximately 200 The key machine in the industry, the paper-making or Fourdrinier machine, which is from 50 to 200 feet long, must be stopped and started every time a new grade of

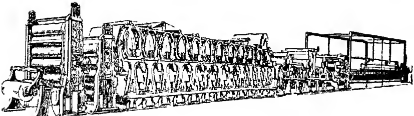
Table 8.1 Some Examples of Variety Reduction

Effected through Simplified Practice Recommendations developed under the procedure of the Commodity Standards Division of the U.S. Department of Commerce

Title	S.P.R. No.	S.P.R. Yr.	Reduction in Variety From	Reduction in Variety To	% Reduction
Adhesive plaster	85	47	26	15	42
Bell-bottom screw jacks	97	47	78	27	78
Cans for fruits and vegetables	155	49	200	32	84
Cast-iron radiators	174	47	33	17	49
Convectors	238	50	1,000,000	1,002	99.8
Cotton jersey cloth and tubing for work gloves	194	48	11	3	73
Cut tacks and small cut nails	47	49	428 sizes	185	57
			423 pks	127	70
Eaves trough, conductor pipe and fittings	29	49	110	79	28
Ferrous range boilers and tanks	8	50	130	13	90
Files and rasps	6	47	661	377	43
Galvanized woven wire fencing	9	47	2,072	200	70
Glass containers for cottage cheese	148	47	24	4	80
Grinding wheels	45	47	715,200	254,400	64
Heave-forged hand tools	17	47	49	21	57
Hospital and institutional cotton textiles	74	49	459	26	94
Iron body valves (pressure ratings)	184	47	12	3	75
Loaded paper shot shells	31	50	4,067	262	94
Medical and surgical hypodermic needles	224	47	55	22	60
Metal-cutting band saws	214	48	127	60	53
Pipe fittings (iron, brass, bronze)	185	47	8,566	2,969	65
Pipes, ducts, and fittings (warm-air heating)	207	49	5,080	1,225	78
Rotary files and burs	233	48	2,000	468	72
Steel reinforcing bars	26	50	32	11	66
Surgical dressings	133	49	5,000	61	99
Surgical gauze	86	47	70	26	63
Tank mounted air compressors (¼ to 10 horsepower)	202	48	347	12	96
Vises (machinists' and related kinds)	229	48	14	8	43
Wire rope	198	50	352	182	48
Welded chain	100	47	1,831	1,214	64

paper is run through it Not only must many time-consuming adjustments be made on the machine, but also there is a huge loss of material from wastage of paper as the machine is being finally adjusted Frequently the down-time cost on the machine plus this wastage is sufficient to cause an addition to the cost of production of 10 to 15 per cent alone, when the runs of paper are short In addition there are the losses incident to idleness of equipment which performs subsequent operations on the paper, these operations vary according to the type of paper being manufactured

Unnecessary diversity of product has resulted from two main causes The first is the demand of the consumer for products that are individually different, to meet either peculiar service needs or individual preferences of



Courtesy Dill & Collins Company

FIG 8 1 Fourdrinier machine

style and taste Successful simplification reflects the buying habits of customers When these buying habits change the simplified practices should likewise be changed Some Simplified Practice Recommendations have been revised over and over again The second, and wholly remediable, cause is that sales methods have frequently emphasized distinctiveness which calls for diversity in production Sales divisions' selling agents and salesmen themselves all have felt that one of their strongest selling arguments was that a particular product was a novelty or that it was different from anything they or their competitors had before presented to the trade, In addition, they have frequently urged retailers to stock a huge variety of the product they sell on the basis of appealing to the consumer's desire for individuality This practice has been frequently unnecessary and costly to the retailer

Securing simplification Simplification can most effectively be accomplished through group effort of many manufacturers working with the Commodity Standards Division of the U S Department of Commerce to establish Simplified Practice Recommendations These recommendations are voluntary standard practices but they are of great value to industry

In the absence of a large-scale effort to reduce the sizes and types of a product, the individual manufacturer may make some progress Cooperation between the sales and production divisions, through regular com-

mittees or special conferences, is the first requirement in developing a workable program of product simplification. The development of a budget of sales and production, as explained in later chapters, is probably the best insurance of successful operation. If this is not practicable, each item of the line should be carefully gone over in the conference between the two departments, and the requirements of each division thoroughly understood by the other before items are either added or dropped from the line of products. Some of the means that have been utilized by individual industries to secure simplification deserve mention. They include the revision of sales methods, the development of a succession of designs if novelty is an important factor, and the development of standardization of parts.

In changing over sales methods to effect simplification, *the change is from arguments based on diversity and price shading to arguments based on* (1) *better goods at the same price or the same goods at a lower price* because of manufacturing economies, (2) *service to the customer,* and (3) if the product is sold through dealers, *quicker turnover* and hence lower investment, damage, and obsolescence charges. Such vital changes in selling methods at times necessitate changes in whole mechanisms of distribution.

Simplification and standardization in style items. It is not true, as claimed by some, that there is no place for a simplification program in highly styled items. In highly styled items standardization over a period of years is an impossibility. In the women's hat industry, despite the importance of novelty, taste, and style, much progress can be made in the standardization of texture of materials, as contrasted with design, and of the inner portions of the articles manufactured. A ladies' hair brush is a style item, nevertheless the number of bristle tufts in the brush and the number of bristles in each tuft could be simplified. Wherever possible, the addition of certain staple styles to the line does much to bring to the plant the benefits of standardization. In such industries standardization can be gained by insuring the elimination of designs of past seasons at the time that new designs are added, thus keeping the total line to a given number of patterns. This idea of *succession of designs* is very important in all industries where taste and novelty enter into retail sales.

Parts simplification and standardization. In mass-production industries parts standardization may be secured to a large measure even if these parts are assembled into a variety of products. Such a program is followed in shoes, automobiles, furniture, and stoves. The automotive industry has been able to standardize largely in the manufacture of parts. Absolute standardization of the finished product has proved to be impossible for any factory, because of varying consumer demands for size, price, type of body,

and color Through the Society of Automotive Engineers the automobile industry led the country in developing standard specifications for bolts, screws, sheet steel, and other component parts In some very complicated industries standardization has been achieved through the leadership of one company Thus, in the pipe-fittings and valve industry the Walworth Company took a very conspicuous part in working toward simplification It announced the elimination of 4½-, 7-, 9-, 11-, 15-, and 22-inch fittings and valves Other manufacturers followed this lead in the elimination of excess variety This saving was achieved through Simplified Practice Recommendation R 57, Wrought-Iron and Wrought-Steel Pipe, Valves and Fittings

The simplification movement The War Industries Board (1917–1918) fostered a program of reducing the number and sizes of products as a measure of conserving scarce materials and labor An illustration of the enormous reductions in variety of product which were brought about under the leadership of this board is the reduction in the number of colors of men's hats to 9, as compared with approximately 100 distinct colors that several factories were previously producing Another example is the reduction of rear gearings of farm tractors from 1736 to 16 Action in the industries closely allied with war operations was quickly followed by action in numerous other industries with a view to general conservation of plant capacity, materials, and manpower Simplification within an industry is essentially a cooperative action, because one large company selling on the basis of diversity can make standardization very difficult for its competitors The United States Chamber of Commerce, observing this fact and seeing the advantages of simplification, undertook an educational campaign through its Fabricated Production Division in 1920, organizing a movement which brought prompt results In 1921 the Division of Simplified Practice of the United States Department of Commerce was formed, and the United States Chamber of Commerce turned over to this new governmental agency the sponsorship of the movement

The organization of the division of the Department of Commerce concerned with promoting simplification of products has been modified from time to time to meet changing conditions It is presently called the Commodity Standards Division The first step in the program is a survey of the industry, to determine the number of current varieties and the demand for each one A tentative program of elimination is formulated for presentation at a general conference composed not alone of producers and distributors, but also of consumers After formal acceptance of the recommendations by a substantial majority of interested groups and individuals, they are published by the department as one of the series of simplified practice recommendations, subject to periodic revision One manufacturer

alone can do little toward simplification unless he dominates the field A trade association which interests all its members in standardization, establishes standards, and works in conjunction with the associations of allied trades, can do much to promote standardization

Effect of standardization upon the worker As operations become automatic and repetitive, they can readily be performed by persons of less skill The development of standardization means the introduction of automatic machinery to perform the operations in the manufacture of the standard product The usual result, however, is not the degradation of the skilled workman but rather the elevation of the unskilled man into a semi-skilled job Standardized products mean less expensive products Markets are expanded, luxuries become necessities, and jobs are created for many more persons through product standardization [4] Mechanization incident to product standardization is but a small step in the progress of the transfer of workers' skills, which started with the Industrial Revolution Industries manufacturing diversified products must mechanize almost as fully as those making standard products The use of process conveyors is not dependent upon the production of only a few sizes of products

Some social reformers who are not acquainted with men at work claim that standardization kills initiative in the workers By working on the same task day after day, however, a man really knows the job and the machine better than the person who first developed them He knows enough really to make suggestions that are practical and can be utilized The man who, working on the same task day in and day out, cannot find play for his initiative in suggesting improvements has no initiative There is a problem in insuring that the worker realizes his relationship to the industry as a whole, but that is true of division of labor under modern conditions regardless of standardization There is one final answer to the objections The tasks of a very large share of workers in industries are so constructed that they do not change whether the product is standardized or diversified To the man working around the dye vat in the hat factory it makes little difference whether hats are made in a hundred or in nine colors His task remains the same, and the technique of his job is not affected

Standard materials Standardization of materials is a prerequisite of effective mass production Naturally, it is not necessary that the best material be purchased This would force all products to be high grade and afford no goods for those with low purchasing power Therefore, standardization of materials takes the form of type standardization, not necessarily the most costly type but that best suited to manufacturing con-

[4] See the article, "Skill," by Anna Bezanson, in *Quarterly Journal of Economics,* August, 1922 This article is just as pertinent today as the day it was written

ditions An outstanding characteristic of the use of standard material is the factor of reliability or certainty Absolute reliability or certainty is not practical, but reasonable manufacturing reliability is both practical and economical The product engineer specifies certain qualities to be desired in the material used and can predict the performance of his product with assurance

Each of the following departments is vitally interested in standardization of materials

1 The product engineering department
2 The materials engineering department
3 The purchasing department
4 The methods department
5 The production-control department
6 The time-study department
7 The manufacturing department
8 The cost department
9 The salvage department
10 The inspection department

The product engineer's interest in standardization of materials The development engineer in a tire plant may call for a particular long-staple sea-island cotton or nylon fabric The tensile strength of this fabric of a given specification has been established as a result of literally thousands of breaking tests in the laboratory If the fabric should not be of the required standard, because of a different twist, shorter staple, or exposure to some chemical, the unaided eye might fail to detect the difference, but the strength would be reduced and the tire-design engineer's careful work would be largely wasted It is because of such situations that materials are tested at great expense As a matter of fact, in modern tire construction the design engineer realizes that his work is largely futile unless standardized materials are used The same principle holds for machine construction, building construction where strength is a factor, and in many other types of production

The quality-control [5] or materials engineer In some industries the materials engineer is a functional officer, sometimes called the quality-control engineer He may be attached to the product-engineering department, the purchasing department, or the research department He usually has a dual function (1) to be on the alert for new materials that may be substituted for those now in use, either as a matter of reducing costs or

[5] Quality control, as used in this sense, refers to the engineer whose basic interest is in the quality of the product or material It is not to be confused with "statistical quality control," which is a device for aiding in the detection of quality deviations, thus aiding in the maintenance of quality standards

improving the product, and (2) to check the quality and use of present materials When the second function is of prime consideration, he may be attached to the inspection department or the purchasing department If he is attached to the inspection department, his influence will be relatively slight The quality-control engineer devotes most of his time to procedures requiring chemical or technical ability, not to routine operational inspection If he is attached to the purchasing department, he will act as an advisor not only to the purchasing department but also to other departments, especially with respect to new materials New products are constantly being marketed, particularly in the chemical and plastics industries The materials engineer may well be in a position to suggest to the product engineer and others substitute materials that are better adapted to the requirements of the product or the manufacturing process

The purchasing department's interest in standards In a survey reported in *Purchasing* in March, 1953, the following replies were given in answer to the question, "Does your company follow the practice of standardization in respect to the purchase of (a) production materials and components, (b) plant and office equipment, (c) maintenance and operating supplies?"

	Yes	Partly	No
(a) Production materials and components	61 per cent	38 per cent	1 per cent
(b) Plant and office equipment	52 per cent	47 per cent	1 per cent
(c) Maintenance and operating supplies	59 per cent	32 per cent	9 per cent

Sixty-nine per cent of the replying companies said they had programs for actively promoting standardization, in all but 6 per cent of the firms, the purchasing departments participated to some degree in standardization activities Eighty-three per cent of the respondent companies said they found established engineering and commercial standards available and adequate to meet their requirements [6] As a result of research on the part of individual corporations, trade associations, and the Federal Government, a great mass of data has been accumulated on various materials Much of this information has been formulated into recognized standards which are available to the purchasing department These standards for materials simplify the work of the purchasing agent Purchasing agents have taken an active part in establishing standards for materials used directly in the product as well as for supplies

The methods department's interest in standardization of materials The methods department is interested not only in standard materials as a means of simplifying operations, but also in making use of available

[6] *The Management Review*, American Management Association, New York, Vol 42, No 5, May, 1953, pp 273–274, has reprinted this survey

equipment It is not at all infrequent for the design to be modified at the suggestion of the methods department to simplify its production or to make use of standard materials already in use in the plant Were it not for reasonably standardized material it would be impossible for the methods department to establish standardized manufacturing procedures

The manufacturing department's interest in standardized materials Any irregularity resulting in below-standard material usually requires additional labor and not infrequently increases the normal scrap from operations When materials do not run true to form, much additional labor is required When the sheet metal draws properly for the fenders, the metal finishers can keep up their end of the work and are usually satisfied with their earnings When 10 per cent additional labor is required because of ripples in the metal, the metal finishers cannot meet standards, and production falls behind schedule The same situation applies to all other operations

The motion and time study department's interest in standardized materials Before the motion and time study department can establish its standard operating times and procedures, it must first eliminate waste motions and secure uniformity in materials Standardized operations must be adopted before time values can be established Standardization of operations can be attained only when both material and machines are standardized, at least to a workable degree When standards are set for a given material, they are presumed to hold until the method is changed If the material falls below the standard set, the method has to be changed, thus immediately destroying the standard This breeds ill will on the part of the employees and tends to vitiate the work of the time study men

Production planning and control There can be no such thing as scientific production control in the absence of reasonably standardized material Even in a job-order plant making products that are not standard in their entirety, a large part of the work is standard If it were not so, production control would be impracticable By having the desired material available when needed and by following carefully a logical sequence of operations, production control reduces the size of the inventory of raw materials to be kept on hand, reduces the inventory of work in process, increases total output, and makes possible the meeting of promised shipping dates

Determination of costs Although it is probably an exaggeration to say that standard costs could not be used without accurate maintenance of material standards, it is true that the use of standard costs under such a situation would be largely ineffective Standard costs are built upon a theoretically desired standard that is capable of attainment under practical operation conditions In turn, standard costs provide management an

excellent means of control Any deviation from the standard of materials used will tend to produce a deviation from the standard costs If the standards are right, to use substandard materials will tend to raise labor costs and thus in the long run either increase the selling price or reduce profits

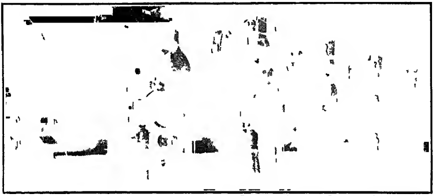
The inspection department's interest in material standards The inspection department plays an important role in quality maintenance, even though the manufacturing department is basically responsible for quality This department tests materials as they come in and as they are progressively processed throughout the plant Quality can be secured in the absence of standard materials, but, as has been pointed out, the cost of maintaining this desired quality in the finished product is high The primary activity of the inspection department is checking the quality of raw materials, work in process, and the finished product against established standards

The National Bureau of Standards The National Bureau of Standards has a long and honorable record of contributing to the scientific development of our country as well as to the effective purchasing of the various branches of the Federal Government The Bureau collaborates with the General Services Administration in the development of new Federal Specifications, and the revision of existing ones, as do other Federal Government establishments Since the Federal Government is the largest single purchaser in the nation, standards established directly by the National Bureau of Standards or through the advice of its personnel exert a powerful influence upon manufacturing practices

9 PROCESSES AND MATERIALS

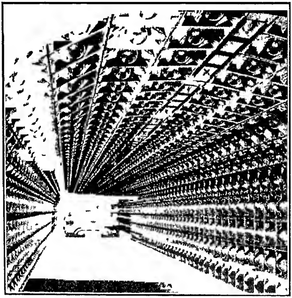
The development of a product is linked inseparably with the availability of certain manufacturing processes and the materials of correct characteristics at the right price, as well as the availability of machines to produce the desired quality of goods at a profit A change in manufacturing procedure usually involves a major decision by management, since it involves large expenditures in new equipment, changes in customer relationships, and at times fundamental changes in the structure of the organization necessary to manufacture and market the product

Reciprocal relationships of researches and developments Research in many branches of manufacturing, often carried on concurrently, creates a closed chain of events It is difficult to find either the beginning or the end of the chain Together, such research projects result in tremendous changes in manufacturing, great outlays for new materials and equipment, strains on the finances of the industrial companies least able to bear the burden of the outlays, and changes in the skills demanded of the working man, with consequent changes of occupation and even in the location of manufacturing communities For instance, the development of electric welding (Fig 14 11) facilitated the use of the wide sheets of steel produced by the strip mills (see Fig 9 1) to give the public the all-steel automobile body The possibility of securing wide sheets for body-building purposes revolutionized the processing of bodies in the automobile industry Die-making machines became taxed to the utmost to produce the huge dies necessary to form one-piece tops The whole structure of the tool and die industry which had been developed to serve the automotive industry was disturbed by the sudden demands for huge dies of this type Few die shops were capable of producing such dies, it was difficult to secure sufficient equipment from the machine manufacturers, and the finances of most of the tool and die shops, usually relatively small companies, would not permit the purchase of such equipment, even if available Thus, much of the die equipment necessary to cope with the new demands was put into the plants of the large automobile manufacturers themselves,



Courtesy American Iron and Steel Institute

FIG 9 1 Finishing stands at a wide continuous hot-strip mill



Courtesy Oldsmobile Division of General Motors Corporation

FIG 9 2 Paint bakes hard as new cars pass through this 60-foot tunnel of infra-red lamps

and they began producing a greater proportion of their own dies than they had made heretofore

The press manufacturers were called upon to produce presses of previously unheard-of proportions (see Fig 14 9) to hold these dies and to stamp out body parts which were formerly made up of literally dozens of pieces The triple-action press illustrated, which shapes sedan panels in one operation, has three moving slides to carry the dies It is more than

Courtesy Link Belt Company

Fig 9 3 Pouring on a conveyor

25 feet high and weighs 600,000 pounds, necessitating the digging of a foundation 106 feet deep down to solid rock Similar presses of a size previously unknown caused production problems for both the press manufacturers and the users until complete knowledge of their capabilities was developed from experience But for the development of the other processes described in this sequence, no demand would have been created for such machines

Figures 9 2–9 3 show interesting processes of baking paint and pouring metal

Steel alloys Nickel is the most widely used alloy to add strength to steel It has been combined with chromium where high-strength stainless steels are in demand and where cost can be figured in terms of long-run economy Where there is a demand for ferrous alloys with high resistance

to rust and corrosion but also with high strength, as in the chemical and food-processing industries, nickel steels are desirable Nickel-manganese cast steels are important in structural parts of railroad cars, tractors, and power shovels, where ultimate strength is the important consideration Common gray iron with nickel alloy has also proved to be a successful and, under many conditions, an economically proper material, fully able to compete with steel castings under conditions where stresses are not too great Within the last 10 years tremendous strides have been made in the manufacture of high-strength cast iron and cast steel

For resistance to corrosion, chromium is the alloying element which produces a condition approaching perfection The electric furnace made possible the development of a multitude of alloy steels at commercially feasible prices The long series of "stainless steels" which have been developed resist the corrosive action of many chemical salts and acids as well as of the atmosphere From tableware to stove and sink tops, from automobile trim to whole trains of stainless steel cars, chromium of varying alloy proportions is today making possible products designed from steel which are as attractive after years of use as the day that they leave the factory and which need no protective coating During World War II, when chromium was exceedingly scarce, an entire series of NE (National Emergency) steels was developed Chromium was still used but in much smaller quantities These low chromium-nickel-molybdenum steels will continue to be used in peace but not in such quantities as during the war

Molybdenum has been used for years with steel to give it strength, hardness, and toughness at high temperatures In alloys this element imparts superior high-temperature properties to numerous working parts With the clearer definition through the years of the results of proper manufacture of steels in the first instance and of heat-treating of steels after manufacture, there has been a constant tendency to reduce the percentage of alloys in the steels and hence to increase the range of their economic usefulness With this attention to the problems concerned with the action of heat on metals has come a knowledge of the greater usefulness of molybdenum as an alloy Plain carbon-molybdenum steel has proved most successful for deep-drawing steels and steels for high-temperature service Chrome-nickel-molybdenum steel has now become a common alloy This steel, with a high carbon content, is to be found in large forgings of many types and in high-temperature forging dies

Tools and dies The long and careful research of Frederick W Taylor and J Maunsel White just before 1900 at the Bethlehem Steel Company resulted in the development of "high-speed steel," the first significant improvement on older carbon steels used for cutting metals It was not only the alloy composition of this steel but also the carefully developed method

of heat-treating it which made it stand apart from all other metal-cutting materials and caused production increases of 400 to 500 per cent with the same machines and equipment. Increased production was aided by the proper utilization of the fast-developing body of knowledge concerning methods of sharpening these tools (see Chapter 14). This high-speed steel had the ability to stand up when run at speeds that heated the tool red-hot. One of the first special steels introduced during the twenties still utilized on a large scale was Haynes Stellite, a cobalt-chromium-tungsten alloy, which, like high-speed steel, maintained its properties at red heat. It machined at high speeds cast iron, malleable iron, and semisteel and could be profitably used on certain grades of steel. Toward the close of the decade there were developed first in Germany and later in the United States a number of tungsten-carbide cutting tools, of which the best known is Carboloy. These new cutting tools at first had limited applications, giving extremely rapid speeds of cut on light feeds for continuous cuts, as on lathes, but cracking or shattering on other types of cutting operations and failing on heavy work. Gradual development obviated most of these difficulties, and this series of cutting tools soon necessitated the virtual redesign of numerous machine tools in order to provide for the stresses which their high speeds set up. Because of the high value of the materials these tools consist of small tips of alloy welded to steel shanks (see Fig. 14.15, p. 146). Other recent developments in cutting tools have made it possible to remove some of the lighter alloys so fast that conveyors are required to carry away the cuttings. Special alloy tool steels have been developed for dies which have increased productivity in equivalent ratio with the new cutting steels and at the same time permit longer operation of the presses on high-production runs without the necessary down time to change dies. Chromium-vanadium alloys have proved helpful in this development, as have the cobalt-chromium-tungsten alloys. Inasmuch as whole dies of any of these materials would be prohibitive in cost, once again welding has made a process commercially possible. The alloy is welded to the wearing parts of the die or is placed in the die in form of inserts. At this point it may also be mentioned that similar wearing surfaces on many types of machinery and equipment are today protected by coatings, edges, or points of alloys in order to resist wear and abrasion. Among the products so protected may be mentioned automobile valve seats, plowshares, pug mill knives, clamshell bucket lips, shredder knives in paper mills, and steam valves. Recently large dies have been covered by carbides using a special flame-plating process. These carbide dies last much longer than the regular steel dies.

Nonferrous metals It was 1886 before aluminum was first reduced by the electrolytic process and many years of experimentation followed

before its price permitted its general use in those parts for which it was best fitted. Aluminum and copper, with its commoner alloys, brass and bronze, have come to be an integral part of the materials for our industries. Magnesium, a metal even lighter than aluminum, has been used on a considerable scale in materials where lightness is all-important, as in the airplane industry. Aluminum, also often used because of its lightness, has excellent properties for conducting heat and has therefore been employed on a large scale in the manufacture of kitchen utensils and for cylinder heads in the automotive industry, to avoid the formation of hot spots above the cylinders in high-compression engines. Aluminum has come to be extensively used also in die castings, nickel being frequently added as a strength-imparting alloy. Beryllium is an expensive metal, but in small quantities it makes possible the heat treating of certain metals, such as copper, lead, nickel, and silver. It has been used most commonly with copper. A beryllium-copper-edged tool can be used in situations where the sparks from a steel tool might produce a hazard, since the beryllium-copper alloy possesses nonsparking characteristics.[1] Porous-chromium surfacing makes possible the use of chromium surface in cylinder walls, piston rings, and similar items. Chromium has one of the lowest coefficients of friction of any of the metals, but smooth chromium will not retain a good oil film. By the Porous-Krome Process the wearing surface is made porous so that the oil film will be retained, thus giving a remarkably efficient surface in terms of low friction.[2]

Copper and silver have both been used very successfully in brazing iron and steel. For some purposes silver is even better than copper, but its expense is generally prohibitive. The shearing strength of a properly made joint exceeds the shearing strength of the copper itself. The laminating of metals has been developed to a state undreamed of 20 years ago. This process has been applied to nickel, Monel, Iconel, stainless steel, silver, and aluminum. Monel metal, an alloy composed of approximately two-thirds nickel and slightly over one-quarter copper, with small portions of other metals, has become a household name in recent years because of its extensive use in kitchen equipment wherever resistance to rust and stains is an important factor. Its use has been somewhat retarded because it is relatively high-priced as a result of the large percentage of nickel which it contains and because of the concurrent rise of the stainless steels.

Plastics. Plastics will play an important role in future industrial developments, but there is little likelihood that they will replace the well-

[1] Archibald Black, "Some Recent Developments in Engineering Material," *Mechanical Engineering,* March and April, 1945, p. 192.

[2] Archibald Black, "Some Recent Developments in Engineering Material," *Mechanical Engineering,* March and April, 1945, p. 193.

known metals except for certain specialized uses Synthetic rubber is a popular name for rubber substitutes but such substitutes are not exact chemical replicas of natural rubber Synthetic rubber proved invaluable for the United Nations during World War II and has appealed to the imagination of the American people Such rubber possesses certain characteristics that make it superior to natural rubber for some uses

Both rayon and nylon are synthetic products that have exerted a profound influence upon the textile industry Rayon has been successfully used in automobile tires The industrial potential of nylon has not yet been fully exploited, but this substance has already made a place for itself in the manufacture of ladies' hosiery The various combinations of plastics, fiber glass, and other materials are almost limitless Traveling bags, ladies' handbags, canoes, refrigerators, radio cabinets, bathroom units, tubes for handling liquids, upholstering materials, and other items have been made from plastics There is a potential plastic for nearly any demand not requiring a high-strength factor The Chevrolet fiber-glass body may be classed as a plastic development In many cases the plastic item is more expensive than its metal equivalent In other cases the plastic is less expensive

Other developments The extrusion process is used extensively in the manufacture of metal and plastic tubing, rods, moulding, and irregular sections In many cases a proper die produces a long piece of material that can then be cut to desired lengths to obtain parts that would be difficult to produce any other way The extrusion process is not new It was used in rubber manufacture 45 years ago, but its wide application in the metal industry is relatively recent Shot-peening has been extensively used to reduce fatigue failure of springs, small parts, and castings The electrolytic process of tin plating, which has been extensively used in place of the old dipping process, conserves tin and yields a more uniform product

In the making of castings four developments have recently received additional attention (1) powder moulding, (2) centrifugal casting, (3) precision casting in plaster investment moulds, and (4) shell moulding Powder metallurgy, as applied to castings, consists in placing the desired powder in a mould under pressure with heat to give the desired casting The metal powder may consist of alloys or any other desired mixture [3] Unusual forms may be secured The casting is very accurate in comparison with the old sand castings, hence very little machining is required Powdered metallurgy has led to the moulding of certain items on a production basis Powdered metals moulding has been applied to steel, bronze, and various other nonferrous metals Centrifugal casting, as its name

[3] See Earle E Schumacher and Alexander G Souden, "Powder Metallurgy," *Metals and Alloys*, November, 1944, pp 1327–1339, for an excellent discussion

implies, is accomplished by rotating the mould while the metal is being poured [4] By this process a better texture of the metal and unusual forms may be secured Precision investment or "lost-wax" casting consists in moulding a wax pattern for each individual casting, forming around the wax pattern a plaster cast of some refractory material, heating the plaster cast to flow out the wax, and pouring molten metal into the plaster cast The wax pattern is moulded in a split-section master mould from a replica or model of the casting, hence it is very accurate in dimensions A new investment (coat of plaster, aromic, or other castable material) has to be made for each casting The casting of the liquid metal may be made under pressure, by the centrifugal method, in a vacuum, or by ordinary pouring Tolerances of ± 0.003 inch have been attained by this method [5] Shell mould castings have been made on a production scale since World War II They are made in a shell of resin-bonded sand The shell is made over a hot metal pattern It is then heated to complete the cure of the resins The shell is then used to make the casting Shell moulding produces an excellent surface finish and high dimensional accuracy It has further advantages (1) reduction in scrap, (2) may be used with a wide range of metals, (3) adaptable to mechanization, (4) requires less sand in the foundry

Other recent developments include the use of sonic energy in making emulsions, inspection, and cleaning small parts, coating steel with an aluminum coating by the hot dip method, flame plating dies with carbide coatings, and inspecting by the use of the X-ray and by the use of atomic energy What the future holds for commercial use of atomic energy depends largely on relative costs and the government's releasing to industry its "know how"

Special production tools Coupled with new machine capacities and new productive capabilities of the alloy tool steels has been the development of tool design to produce special cutting tools which result in tremendous savings Almost any issue of the many magazines that cover processes and machines will have pictures of transfer machines (see Fig 14 3) or other special-purpose machines that reduce manufacturing time and reduce costs The machine-tool manufacturers can produce almost any type of special-purpose machine provided the volume of production will justify the expense incident to the development of the special-purpose

[4] See Gerald E Stedman, "Unique Centrifugal Steel Casting Method," *Metals and Alloys*, November, 1944, pp 1311–1315

[5] See Archibald Black, "Some Recent Developments in Engineering Material," *Mechanical Engineering*, March and April, 1945, p 195, see also Fred P Peters, "Selecting Production Methods for Small Parts," *Metals and Alloys*, July, 1944, p 193 These are excellent articles

equipment Figure 14 2 shows a high-production gear shaper that will cut a gear with 51 teeth in as short a time as 22 seconds

Heat-treating Heat-treating also produces in a metal certain desirable conditions and properties which have a relation to its work ability (Fig 9 4) Heat-treating includes quenching by immersion in liquids or gases, hardening, or heating and quenching from the critical temperature at which the molecules of metal are rearranged, annealing, or heating and then permitting slow cooling of the metal, case hardening, or heating the metal in contact with carbon, so that some of the carbon will be absorbed by the surface of the metal, and then hardening further, and cyaniding, or heating the metal in contact with a cyanide salt, followed by quenching Effective heat-treating in industry has become possible through the development of temperature-control devices which provide proper temperature relationships throughout the heating cycle or in the quenching bath These instruments have become the key to successful heat-treating Distortion in hardening is now controlled through a more thorough understanding of the heat-treating process and a consequent design of parts to prevent such distortion Research into heat-treating problems has proved to be particularly helpful in correcting material conditions traceable to previous processes and at times to steel making itself

Courtesy The Ohio Crankshaft Company

FIG 9 4 Tocco process of hardening the bearing surfaces of a crankshaft in a few seconds

Die casting Die casting is a process of casting articles in permanent moulds on a production basis using automatic or semiautomatic machines that fill and empty the moulds The die-casting operation in its simplest terms involves merely flowing metal into a die under pressure and keeping it there the time required for it to solidify Die casting permits the making as a single unit a product or component which otherwise would have to be composed of a number of individual units, joined by welding or some other

fastening method Elaborate designs may require the operator to insert cores or steel parts The design and composition of the steel die are easily seen to be the vital factors of this operation, and the intricacy of the finished product is limited only by the ability of the die makers to produce practical dies Die castings find some competition from moulded plastics, an important industrial material referred to earlier in this chapter, but are also used to some extent in conjunction with plastics, as in grocery scales, where the die casting may form the structural part of the device and the plastic the moulded casing

Welding In welding, metals are united by one of two general methods (1) plastic processes, in which pressure and heat produce the weld, and (2) fusion processes, in which the application of heat to the metal without pressure makes the weld From a practical standpoint most plastic welding done in manufacturing today is resistance welding, that is, the heat is produced by the passage of electric current through the parts to be joined Such welding is referred to by a variety of designations, depending upon variations of the process employed, some of these terms are butt, flash, spot, seam, and shot welding Butt and flash welding are used to join the ends or sides of tubes, bars, sheets, or similar parts in raw or partly finished condition In butt welding the pieces are pressed together, and an electric current is passed from one piece to the other, causing a slight melting at the ends and a resulting union of the two pieces In flash welding, used particularly for welding sheets and stamped parts, the pieces are drawn apart slightly after the current has been applied, and the resulting arc fuses the surfaces to be joined Pressure is then applied to complete the union Many specialized machines have been developed to produce welded parts by the flash-welding process Spot welding utilizes welding equipment with two electrodes on opposite sides of the pieces to be joined As current flows through the pieces, it heats the area immediately between the electrodes to welding temperatures, the pieces being joined by pressure applied by the machine through the electrodes This process is used to weld small stamped parts to large ones, for instance, bolt holders to enameling sheets in stove manufacture It is a very rapid operation, for if proper fixtures are supplied, dozens of spot welds can be made in a minute Seam welding is a modification of spot welding, used when continuous seams are desired between the metals to be fused, the electrodes being wheels that roll over the surface of the metal being welded A modification of the seam-welding process is used in automatic welding machines employed in the manufacture of welded steel pipe, which is made from coiled strip steel run over a series of rollers and thereby bent into pipe, and then welded Shot welding is a specialized type of resistance welding

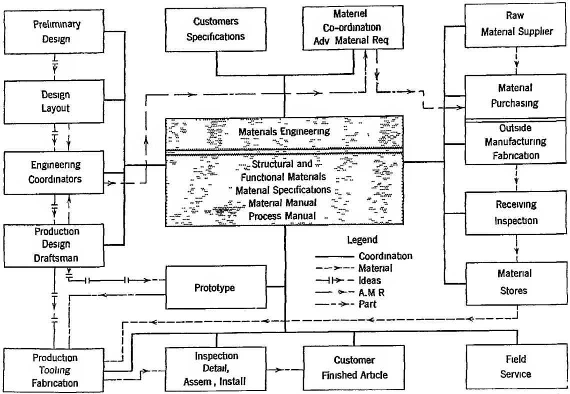
developed and patented by one large manufacturer of welded equipment, the E G Budd Manufacturing Company of Philadelphia

The most popular fusion processes of welding are the electric-arc, atomic-hydrogen, and the oxyacetylene methods In addition to production work these processes are used in portable apparatus for making repairs on machines and equipment In the electric-arc process either metal-arc or carbon-arc methods may be utilized In metal-arc welding the current passes from a metal rod to the work The heat of the arc causes melting of the edges of the work and the rod, so that molten metal from the rod is deposited on the work, causing the fusion In the carbon-arc process an arc is formed between a carbon electrode and the work, metal being deposited upon the work from a welding rod held in the arc Large plates, large pipes, and tanks are welded mainly by the electric-arc process Oxy-acetylene welding utilizes a flame produced by burning a mixture of oxygen and acetylene in a blowpipe This flame can combine a wide variety of metals of different grades and characteristics At times a welding rod, which melts at lower points than the metals being fused, is advantageous in welding several metals of diverse physical characteristics The oxy-acetylene-welding flame can be made to have an oxidizing effect by increasing, or a reducing effect by decreasing, the amount of oxygen in relation to the acetylene This flame is most valuable in welding metals of varying characteristics, the reducing effect being particularly desirable in welding rolled sections to castings

Welding simplified many constructions and eliminated complicated castings As a result of the development of surface finishes, together with the improvement in steel-stamping processes, welding can be used to give the industrial designer, the manufacturer, and the consumer modern products with pleasing streamlined effects, in which rounded corners and the absence of seams are most important

Electrical controls Automatic machines operate without specific control by a worker Some of this automaticity is attained through perfection of machine design, including cam arrangement, and some has been achieved by hydraulic and pneumatic means, but by far the largest part has come from electric controls The machines are ordinarily actuated by the electric motors applied to them, which in turn are controlled by intricate devices, timed to provide a means for bringing into play each function of the machine at just the right time in relation to every other function The solenoid coil forms the basis of operation of many of these control devices Other electrical developments which have come to have general industrial significance are the photoelectric cell and the vacuum tube [6] The

[6] See Keith Henney, *Electron Tubes in Industry*, McGraw-Hill, New York, 1937 p 498



Courtesy Northrop Aircraft Inc and Materials and Methods

FIG 9 5 The materials engineers are associated with materials from the drawing board through the production cycle to the installation and service life of the product Solid lines indicate direct lines of contact Broken lines show flow of ideas and materials which are wedded in production to become parts and products

photoelectric cell is of particular importance in controlling colors of product, the vacuum tube has been utilized in many types of control, such as recording the moisture content in the manufacture of paper In this control a rayon ribbon stretched across a tube and held just above the paper going through the machine becomes longer or shorter, depending upon the moisture in the paper A radio measuring device in the tube transmits these changes in length to a meter, which can easily be read by the machine operator, he then makes any indicated adjustments to bring the moisture content to normal The heat of molten metal is now checked by a pyrometer Formerly much of this work was done by a skilled operator who relied upon his experience to know when to pour the molten metal Today's science provides more accurate controls than the skill of the worker

The materials engineer Figure 9 5 portrays the relationship of the materials engineer The materials-engineering group is usually small but made up of specialists in chemical engineering, metallurgy, physics, and a combination of these and other special skills

This chapter is somewhat technical It is presented as general information and not for technical mastery

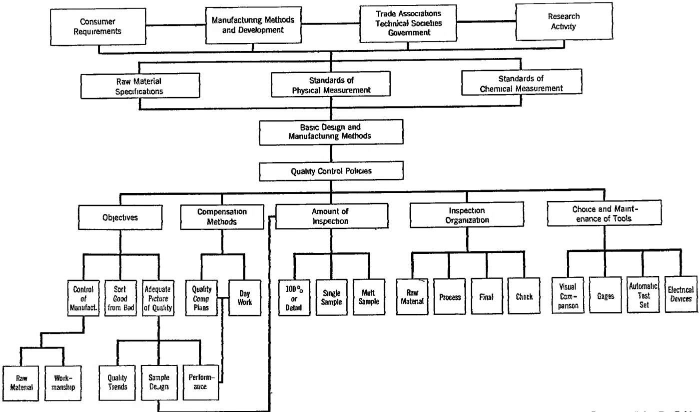
10 INSPECTION FOR QUALITY CONTROL

Definitions *Inspection is the process of measuring the qualities of a product or service in terms of established standards* The quality of a product may be defined as the *sum of a number of related characteristics, such as shape, dimensions, composition, strength, workmanship, adjustment, finish, and color* Standards of quality should be a matter of record wherever possible If these characteristics are not capable of adequate expression, they should be illustrated by a sample of the product showing the desired qualities, the product being inspected may then be compared with the sample It is not always easy to describe certain desired qualities, such as the abrasion-resistance ability of a given tire-tread design Description may be required in terms of a standardized test, such as amount of wear when run at a predetermined speed for a certain length of time under a specified load on a particular describable abrasive-track wheel

Quality control, to most operating persons, means the same as inspecting to see that quality standards are met To some persons *quality control* refers to the use of statistical devices for charting actual quality as determined by inspection It is better to use the term *statistical quality control* to indicate the activities associated with these techniques The *statistical quality-control* function may be a separate unit from actual inspection, it may in a very few cases be the big division of which inspection is a department, or it may be a department of the inspection division reporting to the director of inspection Some of the most effective statistical quality-control operations are handled as a staff function reporting directly to the plant manager and acting independently as a service group to the related activities of design engineering, production, and inspection Figure 10 1 graphically portrays the interrelationships of the various departments with the inspection department

The inspection function [1] Inspection may be classified under at least four different headings, depending largely upon the point of view or emphasis at the time of classifying

[1] See American Management Association, "Planning for Efficient Production,' *Manufacturing Series,* No 206, pp 15–21



Courtesy John D Golder

FIG 10 1 Chart showing the origin of quality control and factors considered in the effective use of quality control

1 Remedial and preventive inspection

2 Centralized and floor inspection, or a combination of these types

3 Materials, work-in-process, finished-product, or final inspection, and functional inspection

4 Visual and nonvisual inspection, such as inspection of chemical composition, tensile strength, or ductility

The objectives of inspection should be made clear to all parties concerned, or unnecessary frictions tend to develop The major objectives of inspection for quality control are as follows

1 To sort acceptable from defective raw materials or work in process, *remedial inspection*

2 To aid in the location of the causes of defective work and cooperatively to assist in removing these causes, *preventive inspection*

3 To control the quality standards of the manufacturing processes, *operative inspection*

4 To provide management, through properly designed reports, with a picture of the quality of the product made, a statement of the quality of the raw materials received, and a measure of the efficiency of plant operations, which is often used as a basis of payment to the worker

The sorting out of defective work in process or finished products protects the good name of the concern, prevents further expenditure on defective parts that must be rejected later, and protects the customer in his purchase To cooperate with the manufacturing group in the location of the causes of defects and to aid in their removal are the highest types of *preventive inspection,* the ones that pay the largest returns on effort expended and the ones that are becoming increasingly important in industry The modern approach to *preventive inspection* utilizes statistical quality-control charts which are based upon sampling inspection at the process *Operative inspection* of quality standards in manufacturing checks on the workmanship of all operations in the plant This control is particularly effective when aimed at preventing future difficulties Process capability studies using information derived from statistical quality-control charts can be indispensable as a real help in *operative inspection* *Remedial inspection* is frequently a necessity in plant operations, but the amount of this type of inspection decreases in proportion to the effectiveness of preventive inspection Sampling plans are available that put *remedial inspection* on a scientific basis Anyone responsible for the choice of a sampling inspection plan by attributes should have available the volume of *Sampling Inspection Tables* by Dodge and Romig[2] To reject raw materials before they are started in production is in reality a form of preventive inspection

[2] H F Dodge and H G Romig, *Sampling Inspection Tables—Single and Double Sampling,* John Wiley & Sons, New York, 1944

The providing of accurate records of the quality of raw materials, work in process, and finished products gives management statistical data for guidance in operating control and policies

Remedial and preventive inspection *Preventive inspection* gives special attention to the accuracy of manufacturing processes in order to avoid defects and waste. *Remedial inspection* strives to discover defects that have already occurred, thus safeguarding the good name of the manufacturer as well as protecting the consumer, and to eliminate further waste by expending additional work on a defective part or product Remedial inspection or *corrective inspection* strives to filter the good from the bad Preventive or *constructive inspection* emphasizes the positive attitude rather than the negative Corrective inspection detects parts that are defective, and the worker is usually required to repair them on his own time or he is not paid for them if they must be scrapped, whereas preventive inspection often is used in connection with a special incentive for quality achievement Preventive inspection does not necessarily have to be tied into any special wage scheme, neither does remedial inspection The major difference between the two types of inspection is the emphasis of one upon detecting defects that have been produced and of the other upon preventing their occurrence

Centralized inspection Centralized inspection usually is performed in a place set aside for the purpose, often within an enclosure especially adapted or equipped Centralized inspection carries the *principle of specialization* somewhat further than floor inspection It does not necessarily follow that there will be only one place in a plant where inspection of this type is carried on As a matter of fact, there may even be two or more places in one large department where parts are taken for inspection Under certain operating conditions and in the case of certain products, centralized inspection has some outstanding advantages, such as the following

1 The inspector's output should be greater because of better working surroundings, less interference, and increased speed arising from specialization

2 It is easier to supervise the inspectors, their tasks may be subdivided, and a less skilled type of worker may be used

3 There should be less interference with the workers in production and better shop housekeeping when the products are not held at the work place for inspection

4 Centralized inspection produces more impartial inspection, at least the inspector is not under the strain of rejecting the work of a man with whom he is in personal contact

5 Centralized inspection facilitates the use of specialized and delicate

equipment such as X-rays, radio amplification, special lights, and air conditioning

6 Records of approved and rejected parts, together with the source of each, are more readily kept under centralized inspection

7 Production control is facilitated when parts pass through a central location, where a total count of approvals and rejections is made

Centralized inspection has some inherent disadvantages, and in some situations, such as in the manufacture of heavy parts or products, it may be impossible Centralized inspection tends to increase the need to transport material, except when the inspection is performed in the stores department or the finished stockroom There also is likely to be an increased inventory of work in process unless the centralized inspection is performed in the stores department or stockroom Centralized inspection is not feasible in progressive manufacturing, at least for the parts, although the final product may be so inspected

Floor inspection Floor inspection is inspection of the part or product at or adjacent to its place of production If the volume of production justifies an inspector's remaining in one place, as on an assembly line or in a given work center, the inspection is relatively stationary as far as location is concerned Not infrequently, however, an inspector may be what is known as a "roaming inspector" and cover a large area The nature of the product, the type of processing, and the inspection itself control the movements of the inspector when inspection is performed on the production floor

Materials, work-in-process, finished-product, and functional inspection The essential characteristics of inspecting work in process have been covered under the discussion of centralized and floor inspection A few other observations in connection with *manufacturing inspection,* however, may be in order In *continuous industries* the general problem of manufacturing inspection is to develop good quality in the final product Frequently the purpose of the inspection work is to rate the product for quality after it is produced In continuous industries, such as the manufacture of paper, textiles, or chemicals, a defect in manufacture is likely to make the material a "second," and there is frequently no possibility of correcting the defect Thus the operation of an inspection department in such industries includes preventing defects wherever possible, noting defects after they have occurred, and deciding whether such defects may be remedied or whether the goods must be placed in a lower classification of products or scrapped Statistical quality-control charts aid materially in detecting defects soon after they occur, and thus the production of large numbers of unusable items can often be prevented In assembly industries inspection includes attention to accuracy of manufacture and to interchangeability

From a production-control standpoint, as well as from the standpoint of the assembly operations, interchangeability of parts in assembled products is essential in order that specific parts, when started in manufacture, need not be designated for specific pieces of final product. Inspection of components during the manufacturing process affords the inspection department an especially good opportunity to practice "preventive medicine" in assembly industries. The objective of the divisions of design engineering and production in a manufacturing plant frequently are in conflict since the specifications are determined in order to insure that a product of the desired quality is produced, and the production foreman is under pressure to maintain an established quota. Tight tolerances can make it difficult to maintain quantity of production at a high level. The inspection department is likely to end up in the middle of this perpetual struggle. Information derived from statistical quality-control charts for variables can be of tremendous help in putting the problem on a factual basis that makes possible the setting of realistic tolerances and then maintaining them.[3]

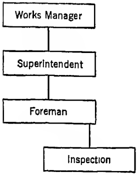


FIG. 10.2. Poor location of an inspection department when quality is of any major importance.

Certain types of products, such as large machinery units, are completely fabricated on the assembly or erection floor and accurately tested by technical experts to determine their operating characteristics. This is known as *engineering inspection*. Large motors, turbines, generators, and similar products are thus tested by the Allis-Chalmers Corporation. In some instances representatives of the purchaser, particularly in governmental purchases, are present at these inspections. Airplanes are usually flight-tested, and steamships given trial runs.

Visual inspection merely refers to the method of inspecting. The name is self-explanatory. This type of inspection has been sufficiently covered in discussions of the other three classifications. *Functional inspection* of parts usually consists of placing the part in a skeletonized assembly and operating it to see if it performs the desired function.

Organization of the inspection department. The inspection department should never be made directly subservient to the will of those engaged in increasing the quantity of production unless quality of work is of minor significance.

If the production foreman has charge of inspection work, manifestly he

[3] See E. L. Grant, *Statistical Quality Control*, McGraw-Hill, New York, 1952, pp. 285–310.

cannot be expected to be rigorous in his application of manufacturing standards and, at the same time, force quantity production through his department (Fig. 10.2). This does not imply that the foreman should not be interested in quality; quite the contrary, the foreman is responsible for

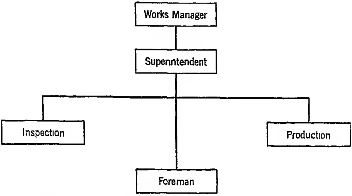


FIG. 10.3. Location of the inspection department when quality is not of extreme importance.

the creation of a quality product. If quality is not of extreme importance in an industry, inspection forces may be maintained as a staff department under the superintendent, as illustrated in Fig. 10.3. The foreman must endeavor to meet both quality and quantity instructions, and, if these instructions conflict, the matter will naturally be referred to the superintendent for decision.

If quality is of maximum importance, as in the production of scientific instruments or in goods sold mainly on the basis of quality rather than the basis of price, the inspection department should be a major manufacturing function directly under the control of the works manager (Fig. 10.4). The

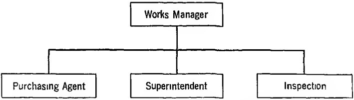
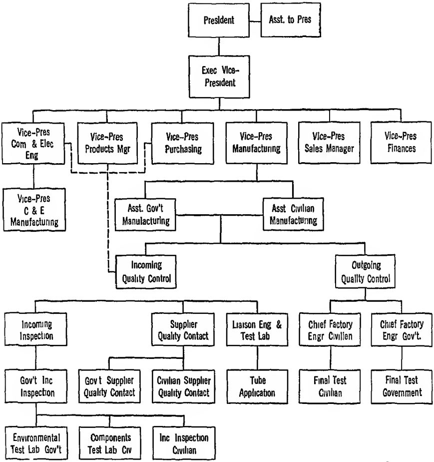


FIG. 10.4. Location of the inspection department when inspection is of maximum importance.

inspection function will thus hold a position analogous to that of the purchasing department or the engineering department on the illustrative organization chart (Fig. 5.5). Figure 10.5 shows the quality-control system of a large radio manufacturing enterprise. It illustrates how intimately the

consumer's complaints affect design and inspection engineering, the sources of most technical standards This chart also shows the progressive inspection from raw materials to finished product Figure 10 6 shows the quality-



Courtesy, Motorola Corporation

FIG 10 5 Quality control organization chart

control system of a large electrical manufacturer This system also exemplifies the closed inspection cycle with the consumer as the end man, both sending and receiving

An inspection department may be organized by having in charge of each operation, department, or unit of product highly qualified inspectors who are responsible for that portion of the work and who report to a chief inspector only on matters of broad inspection policy Instead, the depart-

ment may be organized so that a large number of inspectors with meager authority do the physical work of inspection, and call the attention of chief inspectors to defects, or have their work checked by chief inspectors This system is particularly applicable in large companies which must have inspection departments with a rather large personnel

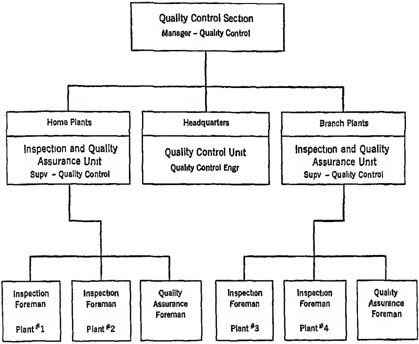
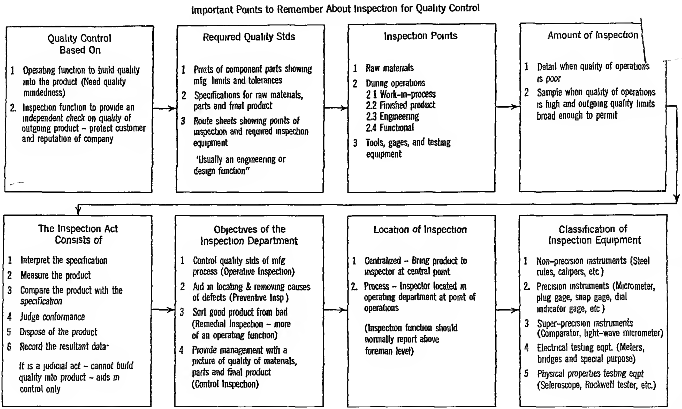


FIG 10 6 Organization chart, Telechron Department, General Electric Company Quality control section

Operating the inspection department The inspection department is an effective aid to the foreman, the planning department, the training department, or the methods department, whichever of these directs the methods of operation and the instruction of the worker Figure 10 7 portrays functions and relationships of the inspection department The inspection department should have full control over both inspection of purchased materials and parts and inspection incident to production The first control enables the department to maintain the material standards which have been set, and the second makes it possible to maintain product standards Frequently the work of inspection incident to production will closely approximate the type of inspection on purchased materials For instance, if the upholstering material is defective, the finished product will not meet specifications



Courtesy Harold Heath

FIG 10 7 Inspection for quality control

When to inspect When to inspect cannot be determined without considering the importance of quality in the product and the possibilities and cost of reworking the product after the various operations It is easy to set up so many quality checks that the responsibility for quality is actually shifted from the shoulders of the workers and foremen to the inspection department This is psychologically wrong, as the workers should be held responsible for quality within the set limits In machining operations of an automatic or semiautomatic nature, parts should be carefully inspected after each new setup until they meet specifications They may then be inspected at frequent intervals just to make certain that there has been no change in the setup and that no serious variation is arising from wear of the cutting tools As a minimum control, the final product should be inspected before it is shipped to the consumer or sent to stock In certain cases inspection should be made after each operation Between these two extremes lies the usual situation In some industries inspection is so important for the ensuing operations and for the maintenance of product standards that it must be regarded as a process in the manufacturing cycle just before assembly operations Usually a series of operations can be grouped, and the product inspected after the last of this group of operations After any operation in which the worker is not readily able to measure quality, however, inspection must be made Analysis of statistical quality-control records based upon pilot runs, manufacturing of similar products, and actual production data often provides the factual information needed to decide intelligently "when" and "what" critical characteristics should be inspected

How much to inspect In high-quality products or those manufactured largely through skill of the worker rather than through the accuracy and operations of the machine, much more of the product must be inspected than is necessary when the machine, once set up, is likely to turn out standard-quality products for a considerable time without adjustment In either situation, overadjustment of a process by an operator is one of the major sources of quality and cost trouble Time and time again this human weakness has been cured to everyone's advantage by putting the job under control-chart operation It is a fact that with the control chart as a guide, less inspection is needed, fewer adjustments are made, and a greater volume of acceptable product results On hand-operated processes, frequently 100 per cent inspection will be necessary, that is, every unit of product must be inspected after each operation The more automatic the machine, the less inspection that need be given after the initial inspection of the setup

Scientific sampling procedures take most of the guesswork out of deciding how much to inspect The major objective, of course, is to attain a desired quality assurance at a minimum cost Appropriate sampling plans can be expected to separate lots requiring 100 per cent inspection

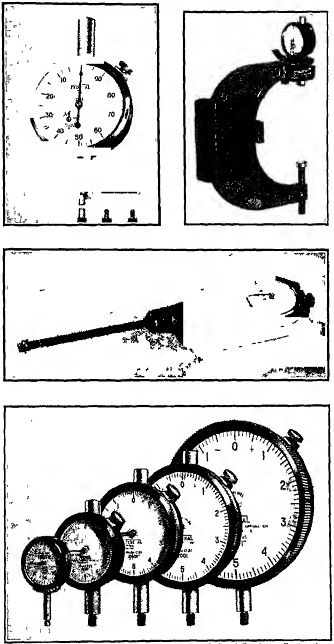
from those which it is safe to accept on the basis of a sample The *Sampling Inspection Tables* by Dodge and Romig are designed to minimize the total inspection required in such situations [4]

How many inspectors? Institutions producing a high-quality precision type of product also require more inspectors than the same general type of industry producing a lower-quality product A continuous-process industry producing a single product will require less inspection than a jobbing type of industry producing many types of quality products Again, if a special-purpose machine is used where volume justifies, the product requires less inspection than the same item manufactured by general-purpose machines It is true that the special-purpose machine itself may require more checking and maintenance than the general-purpose machine, but the maintenance group is not usually classified with the inspectors The organizational setup may also influence the number of inspectors required Where the direct supervisory force is adequate to keep a close check on the quality of production, the amount of inspection necessary to measure quality is reduced Modern precision equipment and statistical quality-control techniques have greatly reduced the number of inspectors required to maintain the quality desired

Inspection on an assembly line On an intricate assembly line, such as a motor assembly, there must be floating inspectors who inspect periodically at the end of one or more of a group of operations In less complex operations an inspector may be stationed at the end of the assembly line, not only to inspect but also to count the number of good pieces for which credit will be given If any parts are thrown out for defects, it is frequently the practice to require the line to make the repairs without extra compensation This arrangement encourages worker inspection as the processes are carried on

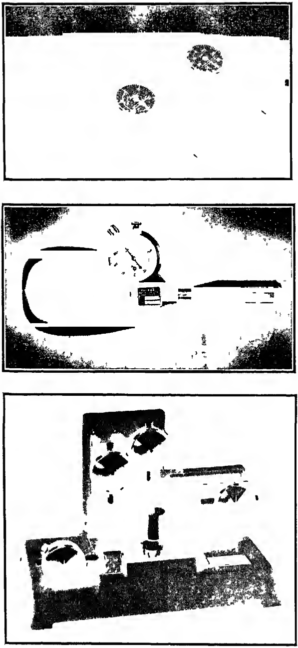
Inspection techniques and devices Inspection standards are a prerequisite of the effective operation of the inspection department There can be no such thing as statistical quality control in the absence of clearly defined standards and data regarding the deviations from these standards These standards should be in writing, if possible, and should indicate the most frequent causes of defects in manufacturing Quality-control charts offer a distinct possibility of tracking down frequent causes of defects so that they can be corrected or eliminated The essential clue to causes of trouble provided by the quality-control chart is the indication of the approximate time that the trouble occurred The standards should be specific in listing requirements, but these requirements should be reasonable in order to secure the cooperation of the production organization Manufac-

[4] H F Dodge and H G Romig, *Sampling Inspection Tables—Single and Double Sampling*, New York, John Wiley & Sons, 1944



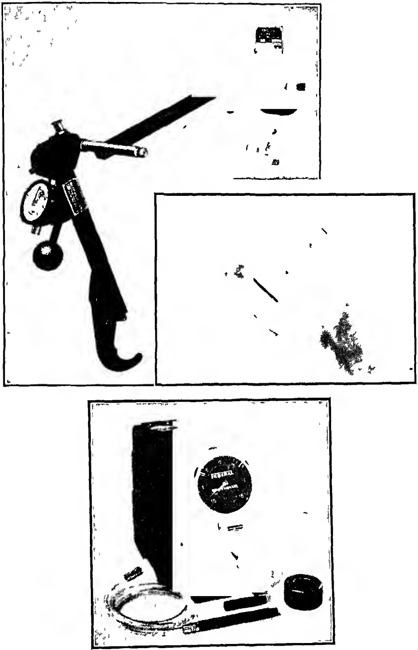
Courtesy Federal Products Corporation

FIG 10 8 Dial inspection gauges



Courtesy, Federal Products Corporation

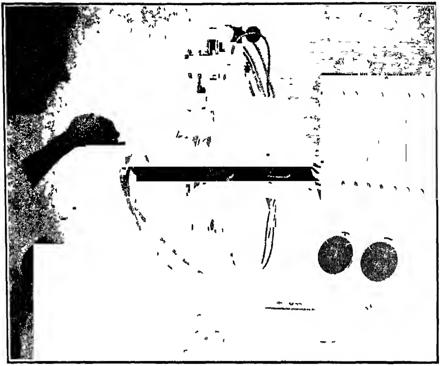
FIG 10 8 (*continued*) Dial production-inspection gauges



Courtesy Federal Products Corporation

Fig 10 8 (*continued*) Production gauges

turing tolerances should be set up with great care in order that unnecessarily high precision and attendant high manufacturing costs will not be required Carefully established tolerances will prevent the waste of unnecessarily high precision As mentioned previously, information derived from statistical quality-control techniques has provided the best solution yet to the problem

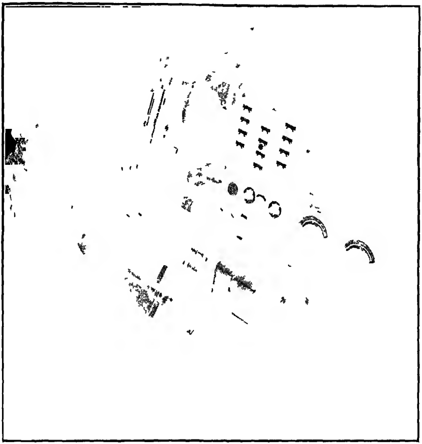


Courtesy Federal Products Corporation

FIG 10 9 Automatic gauge that measures the wrist pin hole and the outside diameter of the piston

of insuring interchangeability of parts and the setting of realistic tolerances The tolerances should not be regarded as the dimension or quality to aim at Many manufacturers have frequently made the mistake of working to limits, with large rejections as the result, in other words, they have aimed at the outer circle of the target, rather than at the bull's-eye

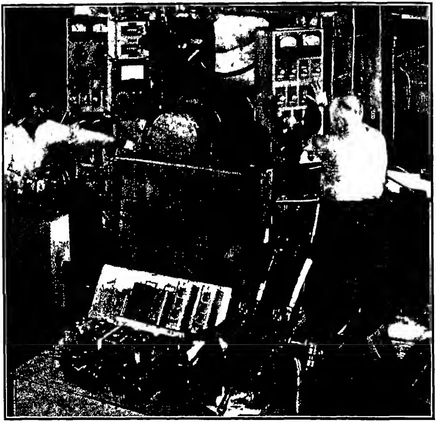
Rejects of valuable parts should be reinspected, perhaps by line-production men, to determine if it is worth while to try to save the units by a special manufacturing process On machined parts "go and no-go" gauges that are set at the proper limits provide a quick way of checking the parts without gauge adjustment Many devices can be set up in the inspection



Courtesy, Ford Motor Company

FIG 10 10 The "memory" of this unique electronic machine enables it to balance crankshafts accurately at Ford Motor Company's Cleveland Engine Plant Ford 6 cylinder engine crankshafts are placed automatically within one-half ounce-inch of perfect dynamic balance by this Tinius Olsen machine, the first in use in the auto motive industry The "scanning screen" at right receives impulses made by revolving the crankshaft If the crankshaft is found to be out of balance, the machine determines "how much" out of balance and "where" unbalance is located Electronic "memory" unit of machine retains all information transmitted to it while the crankshaft was revolved previously Then, with the crankshaft held stationary, the machine automatically sets drills in action which remove exact amounts of metal to restore perfect balance

cage or on the inspection bench which will determine positively whether a part is good or bad without elaborate adjustments (See Fig 10 8 for a variety of gauges used in industry)



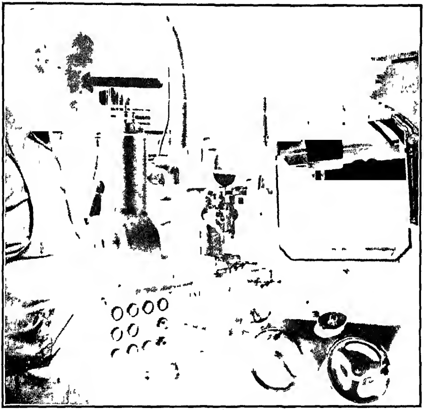
Courtesy Chase Brass and Copper Company

Fig 10 11 X-ray enclosed in a ray-proof case provides extremely accurate control of metal thickness The X-ray signal may also be used to actuate a servo-mechanism to spray a paint marker on areas where this sheet varies from a predetermined standard

The different types of inspection equipment may for convenience be divided into five groups, namely, production gauges, automatic testing equipment, the X-ray and similar devices, electrical devices, and laboratory equipment Figure 10 9 illustrates a special inspection device for inspecting a mass-production part This particular equipment gives ten dial readings at one time Similar mass-production inspecting equipment may be constructed for almost any part where the volume justifies the cost in-

volved Inspection aids vary in complexity from the simple plug gauge all the way to the complicated machine for inspecting crankshafts (Fig 10 10) and the X-ray machine (Fig 10 11)

Gauges In the metal trades in addition to the micrometer, familiar to students of high school physics, gauges may be classified according to their



Courtesy Cincinnati Milling Machine Company

FIG 10 12 Projecto form for optical projection profile grinding Note the comparison of the actual with the templet

purpose working gauges, inspection gauges, and master gauges Working gauges used by the workmen in performing the operations are limit gauges for checking each step as it is performed Inspection gauges are used by process inspectors to check the product before its final assembly with other parts or before sending it to stock Plug gauges are among the oldest and simplest tools used in inspection They consist of pieces of metal turned to the maximum and minimum dimensions It is customary to in-

corporate these two dimensions into one gauge to facilitate rapid inspection, thus producing a two-step plug gauge Inspection consists of inserting the gauge in the hole and observing the fit Profile or contour gauges perform a function similar to that of the plug gauge but measure contours Figure 10 12 illustrates a comparator gauge for checking the work against the standard Figure 10 13 illustrates the multiplying lever indicating gauge, the principle of which has been adapted for many types of operations and processes, from checking the thickness of a given part already processed to checking the product during continuous operations, such as gauging the thickness of fabric as it is being rubberized while going through a calendar or steel as it is being rolled Master gauges are the gauges which are used for checking working and inspection gauges These gauges are accurate to a very high degree and usually consist of discs or blocks ground to exact dimensions They are used to check the operating gauges by having the production gauge check the dimensions of the known master

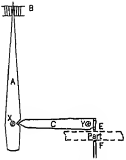


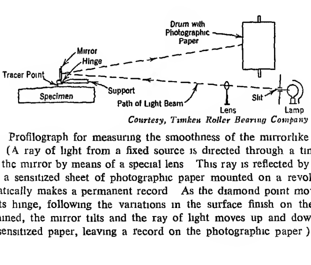
Fig 10 13 Multiplying lever indicating gauge

Automatic testing devices The photoelectric cell and electronic devices have made it possible to build automatic inspection equipment that is more reliable than the individual worker's efforts Some applications to industrial inspection include detection of fine cracks in polished surfaces, inspection of storage battery caps for vent holes, control of enamel thicknesses on wire, rejection of dull razor blades, color measurements, the calipering of steel balls, the detection of whether or not cans have been properly filled, and gauging the thickness of steel while it is being rolled Other uses of this mechanism include the grading of cigars and tile, the detection of missing labels on canned goods, the inspection of tin plate, and the matching of false teeth

Figure 10 14 shows the machine that draws microscopic lines on gold-plated blocks that form an exact standard of "surface roughness " These "surface roughness" blocks are the result of seven years of joint research by the Chrysler Corporation Engineering Division and the General Motors Research Laboratories Uniform precision in surface roughness measurements to one millionth of an inch are made possible through these Precision Reference Specimens of Surface Roughness Figure 10 15 graphically portrays the Profilograph of the Timken Roller Bearing Company of Canton, Ohio This Profilograph, using a ray of light, can accurately measure in terms of a millionth of an inch (0 000001 inch) variations in surface

Courtesy General Motors Corporation and "Automobile Facts

FIG 10 14 Microscopic lines drawn by this machine on gold plated blocks form an exact standard of "surface-roughness"



Courtesy, Timken Roller Bearing Company

FIG 10 15 Profilograph for measuring the smoothness of the mirrorlike surface of a bearing (A ray of light from a fixed source is directed through a tiny slot and focused on the mirror by means of a special lens This ray is reflected by the mirror and strikes a sensitized sheet of photographic paper mounted on a revolving drum and automatically makes a permanent record As the diamond point moves up and down on its hinge, following the variations in the surface finish on the specimen being examined, the mirror tilts and the ray of light moves up and down over the sensitized paper, leaving a record on the photographic paper)

Courtesy Mechanics Universal Joint Division of Borg Warner

FIG 10 16 Universal joint being tested under water In the tightly sealed assembly is a special compound that becomes blood-red when it mixes with water If the coloring does not appear the joint is properly sealed

Courtesy General Motors Corporation

FIG 10 17 In this 4 minute test 500 gallons of water under pressure hit a Chevrolet while a vacuum is maintained inside the body Testing for body leaks

finish Figures 10 16 and 10 17 show two production-inspection procedures

The X-ray, electronic gauges, and beta rays from radioisotopes Electronic gauges have been designed to measure surface finishes to one millionth of an inch Radioisotopes have been used in controlling and gauging the thickness of sheet metal, paper, rubber, plastics, and other products as they came off the assembly line [5] The X-ray machine is usually associated with the medical or dental profession or the research laboratory Its most extensive use in industry is in connection with the examination of steel and iron castings and rolled steel sections for internal flaws Such defects can be detected before expensive operations are performed on these parts

Electrical devices Electrical test sets are used extensively in the electrical and automotive industries Their prime purpose is to test the electrical characteristics of a component part or to check the proper action of the final assembly In the electrical industry, for example, they are used to check the proper winding of armatures and field cores The stroboscope is a device which enables an inspector to study the action of an object moving at high speed to determine any irregularities due to vibrations, eccentricities, or detective parts By its use a given tooth of a saw revolving at 7200 cycles per minute can be studied as if it were standing still

Laboratory equipment Almost every type of laboratory equipment is used somewhere in industry for inspection purposes Chemical analyses of almost every description are used in some process controls, as also are tests for physical characteristics, such as hardness and tensile strength The steel industry makes use of both types of tests The rubber industry, particularly in its compounding and curing operations, makes extensive chemical tests

Statistical quality control [6] For sake of discussion, the techniques of statistical quality control can be divided into two major parts

1 *Control charts* which are based upon sampling at the process

2 *Acceptance sampling* which may be applied at any stage of the manufacturing operation It is often used by purchasers to check the quality of products received from vendors

The functions of *control charts* in a manufacturing process are similar to the job of a detective in attempting to establish the possible guilt of a person suspected of a crime In both cases, associations in time are essential facts needed for solving the problems Control chart applications are based upon the principle that some quality variations are inherent to any pro-

[5] See *Factory Management and Maintenance*, Vol 3, No 4, April, 1953, pp 86–95

[6] Most of the material on statistical quality control was provided by Dr Richard Henshaw of the Bureau of Business Research of the University of Texas

duction process The setting of tolerances and the manufacturing of a product are recognized as inseparable problems Control-chart analysis of pilot runs and data relating to similar manufacturing methods are used as indicators of the probable capabilities of various processes Information about the process is summarized in regard to its ability to hold a given average and as to variation (degree of uniformity) about that average Beyond a certain point it has been found to be impractical to eliminate chance variations From statistical measures of such chance variations the so-called *natural process dispersion* is estimated The natural process dispersion tells the design engineer what specifications the process can meet while under control The use of control charts in the subsequent manufacturing operation shows whether or not the product is being produced within the desired tolerance limits Shifts of process average and variations in excess of the natural process dispersion are indicated by *out-of-control points* on the charts It is important that the sample be inspected promptly after the items are produced and the results immediately plotted on the charts Thus the exact time that assignable causes of variation occur will be indicated by out-of-control points, and such information is invaluable for identifying and eliminating manufacturing troubles Equally important, the control chart tells when to leave the process alone

The control-chart approach operates on the theory that it is better to make the product right in the first place Control charts are primarily a diagnostic device, and although their use often makes possible a substantial curtailment of inspection, this is distinctly a secondary objective

Many successful applications of control charts are based upon 100 per cent inspection, with the contribution in such cases accruing from the detection and elimination of sources of trouble However, in most cases it is possible to reduce the amount of inspection needed through continued use of the control charts

Measurements on continuous scales are said to be expressed by variables, while classifications on the basis of conformity or nonconformity of articles to any specified requirements are said to be expressed by attributes

Problems of controlling variables (i e , dimensions, weights, tensile strength, etc) are attacked by use of control charts for $\bar{X}$ and R, or for $\bar{X}$ and σ [7]

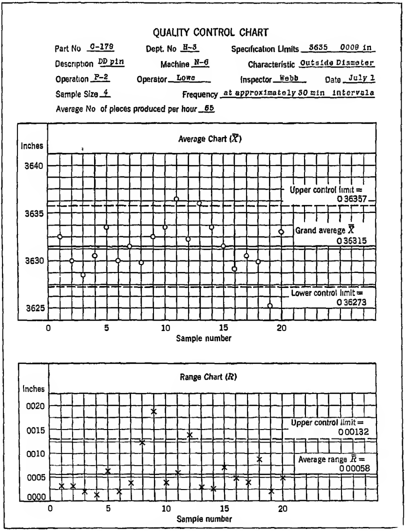
Control of quality where the articles inspected are simply classified as either acceptable or defective utilizes the control chart for fraction defective p

A third type of control chart is useful for regulating the number of defects per article or per unit sample This is called the c chart and may be

[7] $\bar{X}$ refers to the average of a sample, and R (range) and σ (standard deviation) are measures of dispersion

applied to such things as number of seeds (small air pockets) in glass bottles, blemishes on painted surfaces, defects in complex assemblies, etc

Control charts for averages ($\bar{X}$) and ranges (R) are generally used together The $\bar{X}$ chart is useful for indicating shifts in process average while the R chart shows changes in process dispersion Figure 10 18 portrays the measurements taken of the outside diameter of a machined part



Courtesy Richard Henshaw, Bureau of Business Research University of Texa

FIG 10 18 Quality control charts

Three points (samples 11, 13, and 19) are outside the control limits on the $\bar{X}$ chart Two points (samples 9 and 12) are outside the control limits on the R chart This indicates the presence of assignable causes of variation in the machining process, i e , factors contributing to the variation in quality which it should be possible to identify and eliminate

Subsequent use of the charts helped find the assignable causes of variation in the process centering, primarily related to machine setting, and the assignable cause of variation in the process dispersion, mostly related to lack of skill of the operator

Retraining of the operator resulted in a significant improvement in uniformity of the product

Some other extremely useful facts which can be derived from this control-chart analysis are as follows

1 If control (in the statistical sense) can be maintained, the natural tolerances of this process seem to be about $\pm 0\ 0007$ inches Therefore, by maintaining statistical control and by close attention to adjustments in process average at a level of about 0 3635 inches, it should be possible to make parts all within the specification limits of $0\ 3635 \pm 0\ 0009$ inches

2 Process average at present is a little too low at 0 36315 inches It should be shifted up to 0 3635 inches so that no parts will be produced below the lower specification limit, which would require expensive scrapping Furthermore, since it is possible to rework any parts for which the outside diameter is occasionally too large to satisfy the upper specification limit, the operator should be instructed to keep process centering adjusted so that it does not fall below 0 3635 This should prevent the production of any parts with outside diameters below the lower specification limit which have to be scrapped

3 If it is found that control of the process can be maintained for long periods with all points falling inside the control limits, consideration should be given to the possibility of eliminating 100 per cent inspection and using the control-chart results instead In this case, measurement of the outside diameter of four parts at hourly intervals might replace 100 per cent inspection with the go and no-go gauges, except when the control chart showed lack of control The quality assurance afforded by an acceptance procedure of this kind might actually be superior to that offered in the case of 100 per cent inspection before the control charts were used The reason for this is that inspection fatigue makes it impossible for even 100 per cent inspection to eliminate defectives from lots of small, mass-produced items

It should be clear to the reader by now that control-charts are mainly used for process control On the other hand, acceptance sampling is primarily a post-mortem operation which seeks to determine the quality of product that has already been produced In many actual situations, a

clearcut division between the purposes of control charts and acceptance sampling does not exist That is, a product is often accepted on the basis of control-chart records, and likewise the results of acceptance sampling are often useful in process control

Just as there are different types of control charts, there are also acceptance sampling plans based upon inspection by attributes, by variables, and by number of defects per unit Most sampling plans by attributes can, in addition, be applied to number of defects per unit problems For all three of the above types of inspection (attributes, variables, and number of defects per unit) sampling plans utilizing single, double, multiple, and sequential sampling procedures are available

Sampling is based upon the principle that a random sample will be representative of the lot from which it is drawn The amount of sampling error to be expected in a random sample has been mathematically proven *to be inversely proportional to the square root of the number of items in the sample* By making use of this and other facts from the theory of mathematical probability, it is possible to determine scientifically how large a sample needs to be inspected in order to attain a desired quality assurance in regard to any given production lots

The adoption of a sampling inspection plan is based on the premise that a *certain percentage of the output will not conform to the standard specifications* An allowable percentage of defective product in any lot inspected may be specified in determining between a satisfactory lot and a rejected lot According to the laws of chance, a sample will occasionally give a *favorable indication for a bad lot,* resulting in the passing of this lot for use in further production or for delivery to the consumer[8] This is often called the "consumer's risk" In addition to the consumer's risk there is another measure, namely, a value for the *upper limit of defective product that will be accepted from any supplier over a long period of time* This ceiling value is known as the "average outgoing quality limit" or "AOQL"

A third factor needed in the choice of a good sampling plan is a knowledge of the average percentage of defective parts existing in the product submitted for inspection This factor, known as the "incoming process average," is obtained from inspection records of previously inspected lots and is an estimate of the expected quality under normal conditions

The *Sampling Inspection Tables* by Dodge and Romig[9] probably enjoy the widest use in industry These sampling plans are of the acceptance/rectification type, that is, the remaining portion of any lot rejected by the sample is to be inspected 100 per cent Properly used, these plans can be

[8] H F Dodge and H G Romig, "A Method of Sampling Inspection," *The Bell System Technical Journal,* October, 1929, p 628

[9] Dodge and Romig, *Sampling Inspection Tables—Single and Double Sampling,* New York, John Wiley & Sons, 1944

expected to minimize the total amount of inspection necessary to achieve any desired degree of quality assurance The user is given the choice of either single or double sampling plans A much wider range of sampling plans can be found in *Sampling Inspection*, prepared by the Statistical Research Group (SRG) of Columbia University [10]

The most recent of the sampling acceptance schemes being used by the armed forces of the United States, Military Standard 105A,[11] is an excellent example of an acceptance/rejection sampling procedure Because of the cost or due to lack of inspection personnel and facilities, screening of rejected lots by the consumer may be impractical Essentially, these sampling plans are designed to accept or reject the producer's process, that is, they accept nearly all of the submitted lots if the quality level of his process is at or better than the acceptable quality level, and they reject a substantial fraction of his lots if the quality is lower than the acceptable level

The three types of sampling schemes which have been discussed apply to inspection by attributes With slight modification they can also be used for number of defects per unit Since by far the greatest amount of acceptance sampling is done by attributes, no further discussion of sampling schemes by number of defects per unit or by variables will be given here [12]

It should be acknowledged here that in actual practice much of the inspection by sampling is not based upon scientific use of statistical methods but rather upon empirical judgment This accounts in part for some of the turmoil in which inspection departments and producing units frequently find themselves

Statistical quality control has increased in popularity during the past ten years Through its use many companies have increased their control over quality, and some have phenomenally reduced inspection costs at the same time It is highly important that a statistical quality-control system be installed by a specialist Having been properly installed by competent specialists, it may be operated by a person of normal technical and clerical ability However, it is by far better not to try to use this technique than to have it installed by a person not qualified both in statistical theory and practice Of course, it must be remembered that statistical quality control does not produce a quality product It merely informs management when things are not going as they should go Management must then take the needed technical action to remove the causes of failure

[10] H A Freeman, Milton Friedman, Frederick Mosteller, and W A Wallis (eds), *Sampling Inspection*, New York, McGraw-Hill, 1948

[11] *MIL-STD-105A, Sampling Procedures and Tables for Inspection by Attributes*, Superintendent of Documents, Government Printing Office, Washington, D C , 1950

[12] A complete discussion of sampling acceptance schemes can be found in E L Grant, *Statistical Quality Control*, New York, McGraw-Hill, 1952, pp 311–437

PART 4 — THE PLANT AND EQUIPMENT

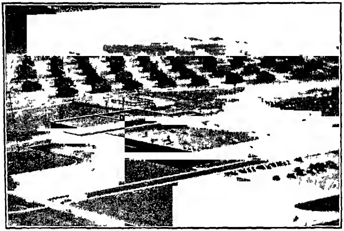
11 PLANT LOCATION

Problems arise Plant location problems arise under any of the following conditions (1) available power or water is not sufficient for production requirements, (2) a lease expires, and the owner of the premises will not extend the lease, (3) the business has outgrown its original facilities, and additions have to be constructed or a new location found, (4) the volume of the business and extent of the market make it desirable to establish branches for either production or distribution purposes, and (5) other social or economic reasons exist, such as an inadequate labor supply, a shifting of the market, or a need to meet competing service given in a special market, and (6) of course when a business is originally founded

Plant location is often the result of a compromise among conflicting social, economic, governmental, and geographic considerations The personal desires of the owners or managers (Fig 11 1), often influenced by social considerations, may suggest one location whereas economic considerations will indicate another Governmental factors are not so important in many instances, but they assume greater significance if the company desires to engage in foreign trade or if the country is at war

Regional specialization Certain regions have acquired a reputation for certain industrial activities, for instance, pottery in Trenton, New Jersey, and East Liverpool, Ohio, brass in the Naugatuck Valley of Connecticut, agricultural implements in Chicago, firearms and fine tools in Connecticut, steel in Pennsylvania, Ohio, and the Great Lakes region, carpets in Pennsylvania, and the scientific optical glass industry in Rochester, New York, the rubber industry in Akron, Ohio, and oil refining in the Houston area

Climatic conditions, natural resources, the general nature of the terrain, and the cultural heritage of the people are influences that explain in part regional specialization Certain types of manufacture, such as the textile industry, require an atmosphere having a high relative humidity Recent developments in artificial air conditioning, however, have eliminated this regional advantage to a large extent



Courtesy Greenwood Mills Corporation

FIG 11 1 A self-sufficient village including 200 brick homes ranging from 4 to 7 rooms, schools, and shopping center is the home of Greenwood Mills Corporation

Factors considered in selecting a plant location One large company with plants in many states has listed the following items as important in locating its plants

1 Regional and community
  1 1 Principal manufacturing activities in the area
  1 2 Availability of fuel, water, and electricity
  1 3 Fire protection
  1 4 Police protection
  1 5 Recreational facilities
  1 6 Schools and hospitals
  1 7 Banking facilities
  1 8 Available housing for employees
  1 9 Taxes
2 Labor
  2 1 Labor supply in the area
    2 11 Skilled and semiskilled
    2 12 Unskilled
  2 2 State labor laws
  2 3 Strike data
3 Transportation facilities (Fig 11 2)
  3 1 For getting materials and supplies in
  3 2 For getting finished products out
4 An economic analysis considering all of the foregoing items

It will be observed that this company does not concern itself with the availability of buildings for its manufacturing processes It is able to build its own buildings to suit its needs Neither does this company con-

cern itself with nearness to raw material as such, since it uses as its raw material the products of other companies such as steel, rubber, and fabric This company does not require any unusual climatic conditions so this item is not included The du Pont Company, in an interesting article in the September-October, 1952, issue of *Better Living* lists the functional activities used in the selecting of the site for their Kingston, North Carolina,

FIG 11 2 California & Hawaiian Sugar Refining Corporation Transportation by water and rail

"Dacron' plant as follows (1) air pollution and weather, (2) legal, (3) industrial analysis, (4) site surveying, (5) construction, (6) land costs, (7) process design, (8) tax liability, (9) power availability, (10) transportation costs, (11) manpower and community, (12) raw material sources (13) site development, (14) economic analysis, and (15) water and waste In considering either of these lists it is seldom that all of the factors are found present in the same degree An economic and industrial analysis usually points to the compromise location that is selected A real shortage of one of the vital items such as water may bar a community that meets most or all of the other requirements

Selecting the exact location After the decision to locate in a given area has been made, the exact site within this area is governed by an analysis of the following factors (1) the availability of land to meet current re-

quirements and the needs of future expansion, as well as the relative cost of this land in comparison with other cost factors, (2) nearness of other industries upon which the given plant may be dependent, (3) transportation facilities for raw materials, finished products, and employees, (4) availability and characteristics of the labor supply, (5) importance of the local market, and (6) community restrictions and, in some instances, community aids The availability of land to meet current requirements and future expansion needs is always important The manufacturing process may be more easily handled in a single-story building, which will require a larger area (If land values are too high, less land space will be used, and a multi-storied structure will have to be built) Provision for expansion is important and often results in great economies in later development An industry that uses a by-product of another plant as its raw material or is a service plant to other plants naturally should be located, in so far as is possible, in the vicinity of the other plant or plants In this way freight charges are reduced, and the service rendered is improved

Governmental factors are important from a regulatory and licensing standpoint Taxes must also be considered Many industries manufacturing for export have established branch plants in Canada and Australia to gain the advantage of a favorable tariff in the United Kingdom Community restrictions, such as requirements for the disposition of wastes, smoke regulations, and zoning laws, are often controlling factors Nearly always an industry in its capacity as a good citizen is unwise to try to break down community regulations, even though it proceeds through regular channels

The local market is of minor importance to the large-scale manufacturer having a wide distribution of his product It is important, however, to the small manufacturer and the manufacturers of bakery goods and other perishable food products Local transportation for raw materials may be handled by truck if the volume is relatively small, yet even in such cases rail and water transportation is often advantageous The presence of transportation facilities for employees or location of the plant near their homes may be reflected in the labor expense as well as in the character of the labor available Many employees use their own automobiles, requiring parking space which is often prohibitively expensive in high-priced land areas

The size of a given market that can be economically served by an individual plant is greatly influenced by transportation rates As far as transportation is concerned, *plants tend to be located in the locality where the aggregate transportation costs are the least*[1] Nearness to the market, definitely tied in with the transportation problem, is also influenced by the

[1] D Philip Locklin, *Economics of Transportation,* Business Publications, Chicago, 1935, p 114

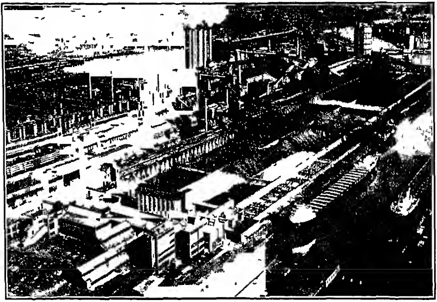
question of the time element in giving prompt service, technical advice, and in the ability to adjust to the trends in the given area The labor supply, particularly for a small enterprise, is usually more satisfactory in or near a city *Nearness to the source of raw material is of special importance when this material is bulky in relation to its value and when the volume and weight are greatly reduced during the processing* If the volume of the raw material is small in comparison to that of the finished product, the plant will usually locate near the market instead of near the supply of raw material Raw materials that are rendered less perishable by the manufacturing operation are nearly always processed near their source Transportation facilities and costs may dictate one location of a plant when the other factors are strongly in favor of another location Water transportation nearly always costs less to the consumer than rail or truck transportation For this reason the Ford Motor Company has located many of its assembly plants on navigable waters This practice, whenever possible, is common for industries having large volumes of freight A region that has adequate rail, water, and truck transportation is definitely to be preferred for the manufacture of a product for a large market

Advantages and disadvantages of the big city The advantages of the specialized region are to be found in abundance in the large city (Fig 11 3), where there are also unusual educational and amusement advantages Not only does the city offer educational advantages for the children of the employees, which may make parents desirous of being in the large city, but also, and more important, there are opportunities for industrial education Evening schools for the workers, discussion groups for the executives, such as advertising clubs and production, and engineering organizations, foremen's training classes, and many other types of educational facilities are to be found in the big city These advantages can also be enjoyed by a firm located in the suburbs, provided transportation facilities are adequate The large city has a diversified working force It is nearly always possible to secure male or female labor as is desired Specialized communities that employ only male labor tend to build up complementary industries employing women, regardless of the size of the community

The advantages of big-city location are offset by some disadvantages The small plant may be forced to find a location in a loft building This type of factory building is particularly common in New York, but it can be found also in other large manufacturing cities The loft building is the refuge of the man who seeks to take advantage of a labor supply near at hand, as in the clothing trade in downtown New York or the textile industries of northeast Philadelphia It is difficult to maintain working standards against the type of manufacturing competition that rents a floor,

rents machines, forgets the existence of overhead, and proceeds to make hay during the sunny times of industry On the other hand, some enterprises in loft buildings meet all the requirements of modern management

In medium-sized cities attractive settings have always been possible, as at the plants of the Eastman Kodak Company in Rochester, New York, and the National Cash Register Company of Dayton, Ohio



Courtesy Automobile Manufacturers Association

FIG 11 3 Large steel mill using both rail and water transportation

The advantages and disadvantages of the big-city location for a plant are

Advantages

1 Adequate supply of labor
2 Presence of subsidiary, service, and related industries
3 Frequently easier financing of the enterprise
4 Large local market for product, of particular importance to the small plant
5 Usually extensive social and educational advantages for employees and executives of the firms
6 Greater availability of trunk-line rail and water transportation

Disadvantages

1 High taxes
2 High labor costs, since living costs and wages are usually higher in large cities than in smaller ones in the same region

3 Labor relations at times less friendly in larger cities than in small communities
4 Scarcity of available sites that provide room foi expansion, and expensiveness of the land

Advantages and disadvantages of the small town The small town's lack of a diversified labor supply is partially counterbalanced by the fact that the town's industries are not likely to absorb the total available labor supply of the community This is particularly true since women have entered so extensively into industry In general the labor relations between employers and employees are favorable in the small community Athough the labor supply is untrained, it is more easily trained in the technique of a given industry than is labor in a large city, because the absence of alternative opportunity makes the workers desirous of learning A diversified labor supply, amusements, and other features are usually lacking in greater or less degree High-grade executives tend to locate near the larger cities The small town offers certain inducements that the large city cannot give A supply of land suitable for constructing a plant to meet current requirements with ample room for expansion is available Undesirable manufacturing neighbors are not likely to be present Municipal regulations are seldom burdensome Low taxes, sometimes coupled with definite rebate of taxes, are another favorable factor Many small towns donate land or even erect buildings and give bonuses to large industries to locate within their borders There is a real danger in placing too much emphasis on such factors if more basic conditions are not advantageous

The suburban location In the suburbs there is adequate land for the one-story structure The ground is relatively cheap, and the taxes are comparatively low The advantages of the big city near by can usually be enjoyed by the staff sufficiently often to keep the workers contented, particularly if the housing conditions in the suburb are as good as or better than in the city Railroad facilities in the suburbs are usually as good as they are in the city In fact, they are likely to be better in that spur tracks are easier to secure and can be arranged to suit the needs of the plant All the advantages of having several competing railroad lines, which are usually found in a large city, may be enjoyed The suburbs of a city provide practically all the advantages of both the large city and the small town with relatively few of their disadvantages This fact accounts for the very rapid development of the "metropolitan districts" near large industrial centers during recent years

The specialized community Examples of the specialized community are flour milling in Minneapolis, cotton spinning in the manufacturing districts of the South, automobile manufacturing in Detroit, and rubber manufacturing in Akron Management problems are simplified in a variety of

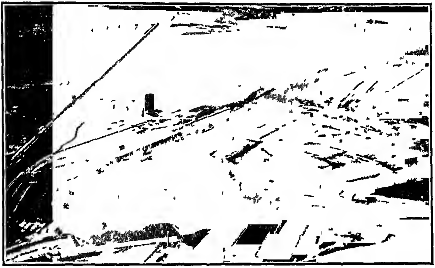
ways by a plant location near other similar industries. Not only is there a trained labor supply available in such localities, but also the ease of financing the business and selling the product is enormously increased. The banks in such communities are familiar with the needs of the business, have a knowledge of good business practice in the industry, and usually are willing to aid in any legitimate way to the limit of their ability.

The proximity of machinery manufacturers who make the type of equipment used in the industry is also another benefit of locating in a specialized community. Required machinery can be procured on short notice, and, more important, repairs to machinery can be secured quickly. If the machinery manufacturer himself is not represented in the specialized center, it is probable that repair shops will soon spring up. This advantage appeals particularly to companies which are not large enough to maintain their own repair departments. Buyers gravitate to localities in which an industry is centered. Sometimes, indeed, a dominating market can be established in the town in which the goods are manufactured. Thus buyers gravitate to New York for the purchase of women's clothing.

In times of depression specialization within a community leads to much "shopping around" by purchasing agents, and therefore the fact that they come to the market to buy is not an unmixed blessing to the manufacturer. Specialization within an area facilitates the unionization of labor within the industry. Manufacturers who do not desire to employ union labor have found this a sufficient cause for moving outside the area. Other manufacturers who are not opposed to dealing with unions have moved their plants because of an unfavorable labor situation in some specialized communities.

A plant may locate in a specialized section and still have a choice of a large city, a small town, or a suburb of a large city. Such a choice is to be found particularly in such sections as the shoe region of New England or the automobile regions of Ohio and Michigan. If the specialized area is a great city, many of the advantages of location within the city can be gained by a location near by, and at the same time some of its disadvantages may be avoided. Thus the automotive plants of Pontiac, Flint, and Jackson, Michigan, enjoy most of the advantages of those located in Detroit, without being faced with the transportation problems or the taxes incident to location within Detroit. The tax problem has played a major role in locating new plants that are branches of larger parent organizations. Pontiac and other "satellite" cities owe their industrial growth largely to the high taxes of the larger cities. This tax differential tends to disappear with the passage of time and the growth of these satellite cities.

The economic survey That plant location *is best which results in the lowest unit cost in producing and distributing the product to the consumer*[2] Determination of it is seldom controlled by one factor alone but is usually the resultant of many economic forces,[2] including (1) incoming freight expenses, (2) cost of fuel, power, and water (Fig 11 4), (3) cost of plant site, (4) building costs, (5) labor costs, and (6) freight costs for the finished product to the consumer With these costs and assumed volume of production, an operating statement can be constructed or a cost analysis made that will indicate certain definite preferences concerning location[3]



Courtesy Houston Chamber of Commerce

FIG 11 4 Houston Turning Basin of the Houston Ship Channel

Most of the data required are readily obtainable from current prices and published schedules for the communities under consideration Labor costs are usually computed on the basis of the prevailing rates in the community for common labor Land sites can usually be determined locally by an actual bid or offer The nature of the land site may determine to some extent the building costs The economic survey may readily be divided into two main divisions (1) the cost of the building and equipment, and

[2] W G Holmes, *Plant Location,* McGraw-Hill, New York, 1930, p 3

[3] See E L Grant, *Principles of Engineering Economy*, Ronald Press, New York, 1952, p 256, for an illustrative computation of relative costs for various locations, and also William B Cornell, *Organization and Management in Industry and Business,* Ronald Press, New York, 1952

(2) the operating costs The building and site cost should be accumulated in some such form as the following

	Location A	Location B
Land	$ 150,000	$ 140,000
Buildings	1,900,000	1,855,000
Equipment	425,000	425,000
Water and power	135,000	110,000
Special requirements, if any		
1 Grading	40,000	11,000
2 Railroad siding	Present	25,000
3 Roadways	11,000	13,000
Total cost	$2,661,000	$2,579,000

The comparative statement of operations for the two sites would be something like the following

	Location A	Location B
Freight expense		
Incoming	$ 150,000	$ 155,000
Outgoing	180,000	178,000
Power and water	65,000	62,000
Fuel	60,000	40,000
Labor	650,000	627,500
Total cost	$1,105,000	$1,062,500

From a purely economic standpoint Location B would be the natural site to be selected Location B has a lower ground cost, building cost, water and power cost, grading cost, but a higher roadway-construction and railroad-siding cost The net cost is in favor of Location B In terms of operations the costs at Location B are also more favorable, and it is evident that Location B is closer to the total market The relative importance of any of the cost factors has to be carefully scrutinized Labor costs vary all of the way from 6 per cent to 70 per cent or more in different industries In the final analysis, from an economic standpoint the total cost relationship rather than any one item is likely to be controlling

Social and governmental factors in plant location National safety in time of war is important in the location of key industries that are a part of the national effort The Federal Government has little, if any, control over the peacetime location of plants, but it enters actively into their location during war It is conceivable that a cooperative peacetime program between management and the government might lead to great advantage in a national emergency It would be a dangerous practice, however, for the Federal Government to exercise any major influence upon the location

of most plants, for political considerations usually do not promote economic efficiency

The social impact of moving a plant from one community to another, particularly when a sizeable operation is moved to a small community, is very great The entire economic and social life of the small community is thrown out of balance Some of the advantages expected are likely not to be realized To move a plant from one location to another involves many social dislocations Labor is not so mobile as many persons believe Deep-rooted ties and sentiments bind workers to a location where they have their friends and sometimes own their homes Some communities become almost ghost towns when a key industry moves out, and thus serious problems are created for the local and state governments

Decentralization in industry Much of the geographical shifting of production involves in reality enlarged or increased production in areas hitherto not actively engaged in this type of manufacturing, rather than a decrease in actual production in the old plant or area The transfer of production to outlying plants, thereby decreasing not only relatively but actually the production in the central plant, constitutes decentralization [4] Since the older production areas and plants may not be increasing production at the same rate as the newer ones, opportunity for the expanding population in this area to find employment is not so favorable as formerly This situation naturally raises grave social, economic, and governmental problems Manufacturing tends to follow the shift in population, and population tends to increase in manufacturing centers, thus establishing a reciprocal relationship Both population and manufacturing centers tend to follow economic opportunities closely related to the abundance of natural resources [5]

Some manufacturers think that there are long-run social and economic advantages in having industry more widely distributed than was the trend at the beginning of the twentieth century There is little likelihood, however, that a large number of widely scattered, self-contained small industrial units will develop It is more probable that the next step in the evolution of regional plant location will be a highly integrated system of plants decentralized in process but directed by a unified management Other factors influencing the growth of industries in new regions (which is what many people mean when they speak of decentralization) are (1) favorable labor legislation or labor relations in the new area, (2) lower labor costs, (3) nearness to the source of raw materials or to the market, (4) cheap

[4] William N Mitchell, *Organization and Management of Production*, McGraw-Hill, New York, 1939, Chap IV, especially pp 62–69

[5] The population center of the United States, according to the 1950 Census, is near Olney, Illinois

electric power, as in the T V A and the Pacific Northwest regions, (5) lower taxes, (6) special inducements in the form of free land sites, and (7) security from attack in time of war

Plant dispersion for national security reasons has not been given the attention by industry that the subject merits Practically all that has been done solely for this reason has been accomplished by governmental pressures when defense plants have been built This is understandable The industrialist is thinking of his own convenience, the convenience of his employees, and the economic factors in locating his plant Dispersion for security purposes frequently runs counter to these interests in the short run

Summary Plant location involves practically every phase of economic and social consideration The social factors exert a powerful influence upon the long-run economic outcome of a given decision The specific site selected usually is a compromise between various considerations The economic survey frequently shows that the large city offers special advantages to the small plant, that the suburbs of a large or medium-sized city are best suited to the fair-sized plant, and that the small town or rural location has much to offer the very large plant in a position to attract its labor supply and able to aid in the housing situation This is a very broad generalization to which there are innumerable exceptions Each individual situation should be analyzed in terms of its peculiar needs and requirements

12 THE FACTORY BUILDING AND PLANT LAYOUT

The Factory Building

The factory building The plant is primarily constructed for the purpose of housing manufacturing processes or the business processes in the case of the department store or bank It is just as logical to discuss plant layout first in a chapter such as this as it is to discuss the building In the initial construction of the building the best-known layout around the existing processes largely determines the building proper The only difference is that the building is a much more permanent structure than the layout For every building there will be many layouts before the building has served its usefulness A recognition of this fact has caused many companies to strive for multi-purpose buildings rather than the single-purpose highly specialized buildings save in a relatively few highly technical continuous-process plants (Fig 12 1) General Motors is building a number of multiple-purpose plants that can be used for defense production or for the manufacture and assembly of automobiles

The factory building is the primary tool with which to carry on production and into which all other production tools and mechanisms must fit Like all other tools, the factory building must be adapted to the operations to be performed if these operations are to be most effectively carried on Defects in factory-building construction are often so primary and organic as to make it almost impossible to remedy them after the building is constructed and production has begun Hence building defects are often of more continual importance than many disorders in other phases of management, which can be made to respond to executive treatment An ineffective plant creates a burden in the daily operations of the business The highly specialized plant is more likely to have outstanding defects when the processes have changed markedly than the general-purpose building

Building the new plant or increasing facilities The motive for increasing or improving present facilities or building a new plant may be traced to any of the following

1 Management desires to have the newest and the best, that is, there is pride in ownership

2 The present plant is not well adapted to the needs of the manufacturing process

3 Sales are in excess of the productive capacity of the present plant

4 Freight rates for the finished product to certain market areas are excessive, and it is thought advisable to locate a plant, usually an additional one, in the market area

Courtesy General Motors Corporation

FIG 12 1 Final assembly and inspection area of Buick-Oldsmobile-Pontiac Assembly Division, Kansas City In this multipurpose plant fighter bombers may be built as well as three makes of automobiles

While a desire for the newest is commendable, it is not justification for permanent commitments in buildings unless these buildings will yield returns commensurate with the expenditures involved This principle is essentially sound even though funds are available for the expenditure If the present plant is not well adapted to the manufacturing process, costs

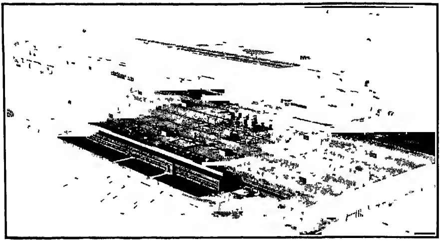
should be compiled to see if the expected manufacturing advantage will justify the increased expenditure It is seldom good judgment to build during the peaks of business prosperity, since costs are always excessive It is difficult for an aggressive management to vote down new construction after several prosperous years, yet this is most often the most opportune time to postpone additional commitments in buildings

A safe rule is to consider the plant in the light of a production tool If the purchase or rent of the new plant may reasonably be expected to yield an increased income over and above all expenses with due regard, in case of purchase, for possible changes in both the product and the process, then and then only should the step be given further consideration This rule will eliminate many unwise ventures Building additional plants in another area raises again nearly all the problems of management, such as methods of control, availability of managing personnel, and expectancy of continued sales volume It requires much more than available funds to run successfully more than one plant A shortage of trained executive personnel may readily be the controlling factor in deciding not to expand at a given time

Building types Where land is relatively cheap, the one-story plant is often favored, particularly if heavy machinery be used in the processing or if the materials or products are heavy The maintenance cost arising from the vibrations of machinery operations is largely eliminated in the one-story building, the machinery being set on especially prepared foundations Layout problems for processing heavy materials are simplified when consecutive operations are placed at adjacent work places This arrangement can be accomplished more readily in one-story structures (Fig 12 2) Some departments grow more rapidly than others, and the extent of this growth often cannot be foretold at the time of laying out the plant The one-story plant provides greater flexibility in meeting this condition Furthermore, provision for the use of natural lighting can be more readily made in the one-story than in the multi-storied plant

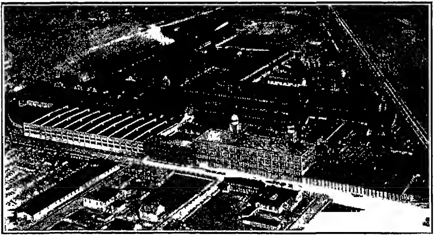
Figure 12 3, illustrating the plant of the Republic Steel Corporation, Canton, Ohio, indicates the manner in which different types of structures are utilized in the same plant to provide necessary housing for the diverse foundry and machine-shop operations of this particular business

With the addition of stories above five or six in a factory employing many workers, the cost per square foot of usable space is likely to increase rapidly, because the effective area is reduced by the service features, such as stairways, firetowers, and elevators The cost of foundations and the space occupied by supporting columns also increase with the number of stories When light material is handled, a multi-storied building is usually



Courtesy, Frigidaire, Division of General Motors

Fig 12 2 The Moraine City plant of Frigidaire is the last word in layout and efficiency Plant service departments are elevated, out of the way, with some extending through the roof

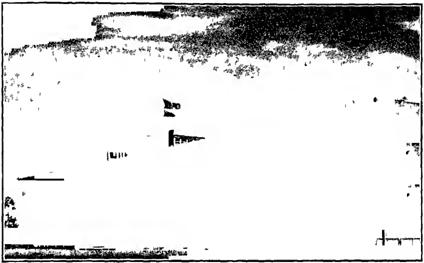


Courtesy, Republic Steel Corporation

Fig 12 3 Berger Manufacturing Division, Republic Steel Corporation, Canton, Ohio

preferred (see Fig 12 4) Multi-storied buildings have distinct material-handling advantages where goods can be moved by gravity The lowest cost per square foot of floor space can usually be secured through the use of three- to five-story structures if the ground is relatively high in value Otherwise the lowest cost may be found in one- or two-story structures

The structural steel building has the skeleton of steel and the walls and floors of some other suitable material The reinforced-concrete building



Courtesy Mergenthaler Linotype Company, Brooklyn, N Y

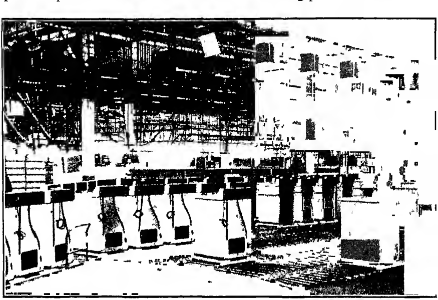
FIG 12 4 Building making use of natural light through the use of Insular glass blocks

is built of concrete and reinforced throughout with steel The building with mill construction has heavy wooden columns, joists, and other structural members It was popular when wood was plentiful but is seldom used today Adequate sprinkler systems must be provided for protection against fire The construction used in partitions greatly influences the flexibility of the plant The tendency is to have as few supporting columns as possible and not to use partitions as a part of the building support In this case, room partitions and fire walls are often built of hollow tile which can easily be removed and rebuilt as changes in layout require

The size of the building The small plant has certain very definite management advantages which have caused managers of large plants to ask, "How large should a factory be?" There is a difference in the personnel problem in the large plant and in the small one No matter how effective the organization or leadership in large plants, it is impossible for

the worker to be in actual contact with the men really running the plant Many management devices have been instituted for the single purpose of minimizing this impersonal relationship as far as possible

As yet we have not demonstrated our ability to eliminate depressions This fact should influence the size of the plant Businesses which have several plants are enabled to shut down one of them entirely during depression periods Businesses that have but one big plant must shut down



Courtesy Frigidaire Division of General Motors

FIG 12 5 Overhead and floor conveyors combine to keep materials and products moving

a portion of that plant This means that the workers throughout the organization are affected because of the shutdown of one small section of the business They naturally ask, "Are we next?" or "Shouldn't we decrease our production so that there will be enough work for all of us?" While the shutting down of a separate plant may affect the other plants it does so much less than the shutting down of a portion of the large plant

The freight rate disadvantage of the large plant manufacturing a product for national distribution (provided the items are substantial in size or weight) is one that is difficult to overcome by the advantages of the large central plant Two of the best examples of a method of coping with this problem that have been largely emulated are the Ford and General Motors organizations The location of assembly plants in many parts of the United States, with the product shipped to them from the main factory

in knocked-down condition, is now the recognized practice of the automobile manufacturers who have sufficient volume to justify it. Similarly, in the steel industry more or less rough shapes are shipped to locations near the big cities and are there worked over or "fabricated" in accordance with the needs of the local community. Procter and Gamble as well as Lever

Courtesy Chrysler Corporation, Detroit, Michigan

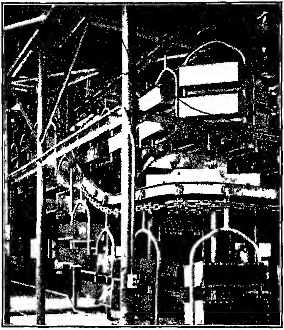
FIG 12 6 New cars move toward completion along the assembly lines at one of the corporation's Detroit plants. Subassemblies carried to the lines by conveyors and materials stored along the aisles are added to the chassis as they move along the final assembly lines. The car bodies stored on the mezzanine are lowered onto the chassis in a dramatic "body drop" operation

Brothers have built plants in many parts of the country rather than produce their products in one central plant.

Plant Layout

Factors influencing layout A theoretically ideal layout for a plant considers the type of industry, the quantity of production, the type of product, the type of operations, and the type of worker. A *continuous industry* is one in which all the material is received at one point, from which successive operations turn it into a finished product, as in yarn

spinning and paper and pottery manufacture. An *assembly industry* (Fig. 12.5) is one in which the finished product can be produced only after various components have been made and then brought together for final operations, such as the manufacture of shoes, clothing, and automobiles (Fig. 12.6). In factory layout this difference is significant. Some continuous industries are synthetic, that is, the product is obtained by bringing



Courtesy Link Belt Company

FIG. 12.7. Overhead trolley conveyors frequently make sharp turns and go up steep inclines.

together various ingredients which are combined in the manufacturing process, as paper manufacture or yarn spinning. Other continuous industries are *analytical,* that is, the product is obtained by successive processes that separate the final product from the mass of original material. All refining industries, such as oil and by-products of coke, are of this nature. The type of worker is a fundamental consideration, particularly in the employment of women workers, where many decisions concerning factory layout must be changed because of the requirements of these employees.

Layout problems in any plant in which the product can be moved, either by gravity or by pumps, from one operation to another, as in flour

or sugar manufacture, differ from those in which work in process must be handled by hand, conveyor (Fig 12 7), or truck in moving from one operation to the next The type of product, that is, whether the product is heavy or light, large or small, liquid or solid, is another fundamental consideration in plant layout Although the manufacture of radios and locomotives both involve assembly work, layout problems differ materially Certain types of operations make it imperative that they be considered first in making layout plans Such are wet operations, as leather tanning or textile dyeing, operations involving heavy machinery, as large hydraulic presses, and operations which involve fire risk, as in the manufacture of powder or linoleum Another factor markedly influences plant layout, namely, the type of manufacture—whether repetitive operations on standardized products, usually involving mass production, are involved, or whether many unlike operations on nonstandard products, frequently referred to as *job-lot manufacturing,* are required The industry that manufactures in large quantities a relatively few standardized products may be laid out on the so-called *straight-line* or *product* basis as well as the *functional* or *process* basis, whereas the job-lot type of industry is almost of necessity largely on the *functional* basis

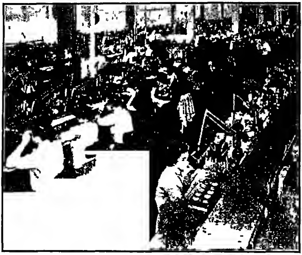
The size of departments Having in mind the problem of supervision a few companies are definitely committed to small departments In these companies a new department is created, possibly in the same area, whenever the volume of work requires more men than it is thought well to place under one supervisor In such companies the layout is designed around the managerial philosophy Similar functions may be split into several departments under different foremen, whose relationship to the entire factory organization is the same as if the work were being performed in one department The element of competition, advocated so strongly by Frank Gilbreth,[1] is a major feature of the multiple-department idea Some companies break their cost controls down on a departmental basis to encourage this competition, even going to the expense of installing individual electric meters for each department

Balance in layout The capacity of each department or of each machine working on each operation should be sufficient properly to absorb the production of prior operations and to transmit to following operations sufficient product to keep the equipment fully utilized Any other plan involves increasing inventories of material in process, overtime work, with its attendant increased costs, and general confusion, including utilization of expensive factory floor space for material tied up while in process There is no formula for determining the proper balance in equipment, especially

[1] See Wm R Spriegel and Clark Myers, *The Writings of the Gilbreths,* Richard D Irwin, Homewood, Illinois, 1953, pp 46–48

in job-lot manufacturing Experience and careful analysis of previous performance are the best guides A change in process or design may destroy an ideal balance Balance is a goal toward which management is ever striving, but which requires constant vigilance to approximate and retain

Production centers Instead of the worker and his machine being considered the unit for which space must be provided, each worker tending



Courtesy Hamilton Watch Company

FIG 12 8 Production center at Hamilton Watch Company, Lancaster, Pa

a group of machines or each machine tended by a group of workers should be looked upon as a production center The production center includes the workmen, the machines, space for storage of raw material and completed units from the operation, supplementary apparatus of any kind needed in the performance of the operation, and a share of the aisle space required between this production center and the next (Fig 12 8) The importance of the machine as the basis of production in modern industry frequently makes a factory floor a succession of similar production centers

Line layout or layout by product A theoretically perfect layout by product would be one in which all parts, subassemblies, etc , would be started at just the right time to be ready when needed and would keep moving until the final product would be removed from the end of the assembly line Layout by product implies that operations are performed in a sequence and that the product is assembled or worked upon as needed Direct-line or straight-line layout, as it is sometimes called, is almost never

found in industry in its pure state, however, it is the most popular type of layout in mass production The ideal of straight-line layout is complicated by the following factors, which are always present in plants producing diversified products

1 The necessity of placing all operations in the production line on the basis of certain considerations, such as the type of product or operation Thus, many operations must have special light, such as cloth examining in clothing plants or wool sorting in woolen yarn plants, where the light should come from the north Tanning vats in tanneries should be placed on solid ground because of their weight and the wetness of the operation

2 The performance of two or more operations by the same worker, as in felling operations in the clothing industry If each part moves quickly and is easy to handle, it may prove cheaper to move the material than to move the worker

3 The use of the same machine on more than one operation in the process It may be inadvisable to provide two machines, particularly if one operation will not keep one machine continuously employed

Direct-line layout is applicable either to a single floor of the factory or to the building as a whole The central idea behind layout by product is a continuous flow of materials in process toward the finished-product stage The advantages of layout by product [2] are as follows

1 Facilitation of the use of material-handling devices and conservation of floor space

2 Minimization of "back hauling" and internal transportation

3 Tendency to eliminate bottle-necks when properly adjusted

4 Shortening of the manufacturing time from the first operation to the finished product

5 Facilitation of production control When a product is once started along the line, it is difficult for it to be sidetracked

6 Reduction of the work-in-process inventory

7 Some reduction of the finished-product inventory, since production control is more complete and promises to customers from production are more reliable

The disadvantages of layout by product are

1 Decreased flexibility Changes in the product may require an entire rearrangement of the layout Job lots are difficult, if not impossible, to handle

2 Increased investment in equipment A machine may be required to perform a certain operation in a given sequence, and the quantity of work to be done will not keep it busy

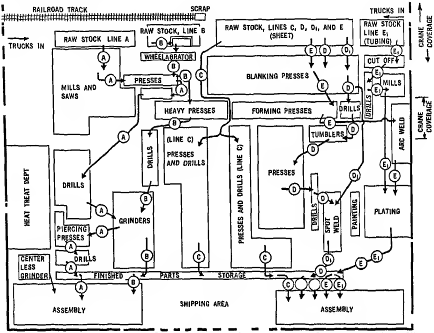
3 Frequently greater difficulty in expanding production beyond the capacities of the lines in layout by product than in functional layout Within the capacities of the

[2] Layout by product does not require straight-line processing, even though the term is often used It merely implies continuous processing Modern conveyors will turn corners and go from one floor to another

lines in layout by product, however, considerable flexibility is achieved by adding or taking off workers and adjusting the conveyor speeds accordingly

4 Greater difficulty in securing specialization in supervision [8] There may be only one spot-welding operation on a line, while there is a great deal of electric welding somewhere else in the shop

Figure 12 9 shows a layout of a job-lot production that has secured many of the advantages of layout by product through the use of material-handling equipment



Courtesy, Atwood Vacuum Machine Company, Rockford, Illinois

FIG 12 9 Unusual layout for this job shop Each block represents a group of machines Lettered arrows indicate main "production lines," flowing from raw materials' stores at top to shipping at bottom Sharing machines by adjacent lines adds flexibility

Layout by process Layout by process or functional layout is characterized by the assembling of similar operations in one place, for instance, all drilling is performed in a drill-press department, and all electric welding is done in the electric-welding department This type of layout carries out the functional idea of Frederick W Taylor It has much to commend

[8] See Franklin E Folts, *Introduction to Industrial Management*, McGraw-Hill, New York, 1954, p 322, for the case of Simonds Saw and Steel Company

it for job-lot manufacturing or the manufacture of nonstandardized products The advantages of layout by process are

1 Greater flexibility, in that changes in operations and the sequences of operations seldom involve a change in layout

2 Easier adjustment to changes in volume of production, especially when it is necessary to add equipment

3 More ready adaptation to special needs arising from certain types of equipment, such as the protection of workers against exhausting fumes or the flashing of light in electric welding

4 More complete utilization of equipment, and hence a lower investment in equipment

5 Better utilization of the skill of the workers by following the principle of specialization

6 More effective use of specialized abilities of supervisors

The functional layout is strong where layout by product is weak, and weak where product layout is strong It is seldom that an industrial enterprise of any magnitude is laid out solely on either a functional or a product basis The disadvantages of functional layout are essentially the same as the advantages of the product type of layout

1 Greater difficulty in automatic material handling and need for more floor space for the same volume of production

2 Excessive back hauling of materials in process

3 More time required to make the same product

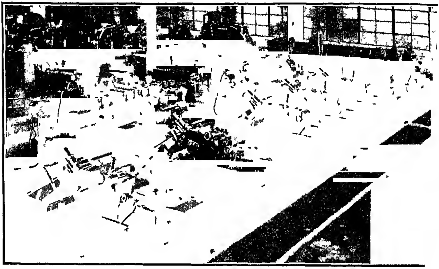
4 Greater difficulty in production control

5 Excessive work in-process inventory

6 Tendency to increase the finished-stock inventory if the same service to customers is given as is accomplished under product layout

Some plants store materials immediately adjacent to the first operation Machines are arrayed so that the finished product of one operation may be passed to the next operation with a minimum of handling If operations are so arranged in standard production that material can be handed or sent in chutes from one worker to another (see Fig 12 10), the ideal of short moves is achieved The same result is often accomplished when the worker receives his work from a moving conveyor and places it back on the same conveyor, from which the worker on the next operation takes it Workers on assembly lines can be placed as close together as material-storage conditions permit (Fig 12 8), but greater flexibility is achieved by having the original line provide for space between workers, which can be filled in later as operations change or production increases Short moves increase in importance as a layout factor if the product is heavy and unwieldy Conveying apparatus, however, has greatly decreased the cost of long moves and has in effect practically put machines or departments at a distance from each other in direct line

Internal transportation Adequate aisle space is the first and most important factor in adequate internal transportation The aisles should be sufficient for all trucking requirements and should be kept clear, possibly by painting white or yellow lines upon the floor Main aisles should be considered separately when space is calculated for production centers Material handling is such an important phase of modern industrial operations that this subject is treated more extensively in Chapter 13



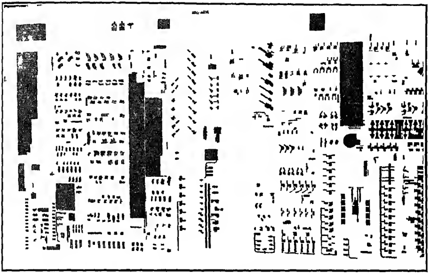
Courtesy Cincinnati Milling and Grinding Machines, Inc

FIG 12 10 Manual handling is replaced by conveyors between grinders, thus making special-purpose machines out of standard machines and standard conveyor units

Service centers The toolrooms, storerooms, dressing rooms, restrooms, and lavatories comprise the service centers of a plant The shorter the distance from the operations to these centers, the less time will be consumed by workers going to and from their work places It is advisable to have the restrooms separate from the locker and dressing rooms wherever possible Frequently, it has been found possible to place the service centers on balconies between floors This is naturally a big space-saver as well as a convenient arrangement as far as proximity to the processes is concerned Another good arrangement for these centers is to place them in divisions of the process or in natural divisions between buildings or parts of the same building In this way these centers are brought into close proximity to the entrances, exits, and elevators

Making the layout Information needed before starting a complete plant layout includes the size of production centers, sequence of opera-

tions or flow chart, size of storerooms needed for raw materials and partly finished and finished products, space needed for toolrooms, auxiliary equipment, office and production-department requirements, aisle space, recreation rooms, service centers, boiler- and engine-room requirements, and all other similar departments or facilities Every square yard of space required should be estimated before final plans are prepared Future expansion should always be borne in mind, and provision made for it A



Courtesy Cleveland Graphite Bronze Company

FIG 12 11 Plant layout of Cleveland Graphite Bronze Company

frequent mistake is failure to provide for expansion or to provide enough space to care for future needs An excellent procedure in making a layout is to cut small scaled templets of cardboard or paper representing each machine or group of machines in the process These should be laid on an outline plan of the building drawn to the same scale (see Fig 12 11) By this means the almost invariable changes and shifts in plan may be made without expensive and time-wasting drafting work By pasting these templets on tracing paper and running them through a printing machine an excellent permanent record may be made of each trial layout It is not unusual to make 20 or more trials before settling on the one selected These shifts are almost always necessary It is best to proceed very cautiously, watching at all times for unexpected difficulties When final arrangement of the templets has been completed and approved, the whole may be transcribed to blueprints

Frequently models of equipment and machines are used in making layouts Figure 12 12 illustrates such a layout of the Chrysler Dodge plant Such models give a three-dimensional effect

Courtesy Chrysler Corporation, Detroit Michigan

FIG 12 12 Exact three-dimension factory models aid management and plant engineers in solving many production problems Above, two plant-layout men at Chrysler Corporation's Dodge Truck plant in Detroit make suggested changes in the general plant layout prior to a management conference

Balance in the layout for wallpaper printing Figure 12 13 shows two arrangements for printing wallpaper The top arrangement portrays the continuous flow of the raw material until it is wound up in small rolls ready to be bundled and shipped to the consumer In order to make effective use of manpower in this multi-line plant, the work of each man is arranged to cover the same operation on four lines of equipment Since it takes several hours to change from one style to another, in practice the worker is attending only three machines at a time, the fourth one being down for a change-over This arrangement of the men is satisfactory for all operations except the final one of tending the automatic roller, which requires the constant attention of one man The automatic rolling ma-

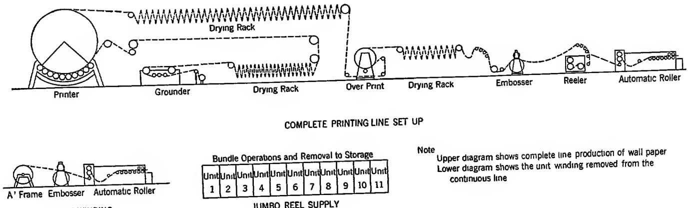


FIG 12 13 Wallpaper-printing layout

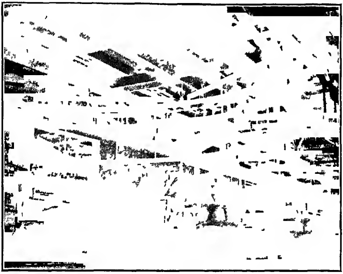
chines can be operated at a higher speed than most of the others It has therefore been found efficient, particularly when running the slow-speed (high-quality-production) setup, to remove the embossing and automatic rolling machine from the line and to perform these operations in a separate unit, as shown in the lower left-hand corner of Fig 12 13 When this is done, the rolls come from the main line in the form of "Jumbo" reels, which are transported to the embossing and rewinding unit to be rewound into the small consumer rolls These small rolls are then bundled into units of 15 or 25 and transferred to stock awaiting shipment This breaking up of the continuous process gives better loading of the mechanical equipment and is more efficient for the short runs and the slower-speed production, even though an additional operation is involved

Automation During the last few years a great deal of attention has been given to the subject of the automatic plant [4] Relatively few companies have the volume required to justify the expenditure inherent in the automatic plant On the other hand, there is an ever-increasing number of automatic installations for individual items in various companies The transfer machines that have wide acceptance in automobile engine manufacturing fall in this class By using modern material-handling devices it is possible to attach two production machines in such a manner as to make them automatic or at least semiautomatic By the application of punched cards and punched tapes to electrical controls of metal-working machines, many of the present worker-controlled operations are eliminated As yet these devices have not received wide acceptance but they undoubtedly will play a larger role in the future than during the past Many of these controls have been developed during the past 5 years

[4] H L Waddel, 'Automatic Production' in *Mechanical Engineering,* March, 1953, see also American Management Association *General Management Series,* No 164, Technical Approaches to Cost Reduction," and also *Manufacturing Series,* No 205, "Automation and Other Technological Advances"

13 MATERIAL HANDLING

Importance of material handling It is estimated that the cost of handling materials is from 50 to 75 per cent of the cost of manufacturing This cost can be reduced by proper layout (Chapter 12) but it cannot be



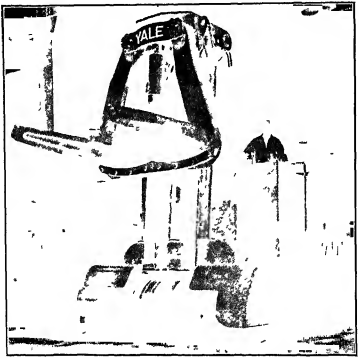
Courtesy Automobile Facts

FIG 13 1 De Soto's body lines take the bodies where they are needed for the required operations This plant has more than 8 miles of conveyors

eliminated The United States leads all the other countries in the world in the use of mechanical devices for handling material This leadership is due in part to our mass-production industries and in part to high labor costs, as well as the desire to remove drudgery from the work process Some material-handling devices promote improved layout by connecting widely separated parts of the factory (see Fig 13 1), some improve the technique of the process itself, some make possible an increase in the

weight and size of the unit of production (see Fig 13 2), and some assist in shipping the final product (see Figs 13 3, 13 4, and 13 5)

The handling of incoming or outgoing freight provides one of the most fruitful areas for savings (Figs 13 4, 13 6, and 13 8) Note the fact that freight cars and trucks come inside the building (Fig 13 4)

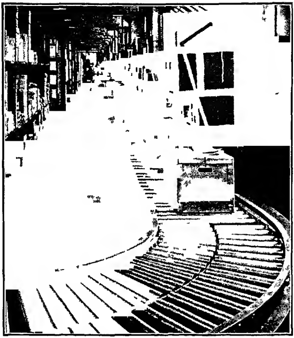


Courtesy The Yale and Towne Manufacturing Company

Fig 13 2 This large lift truck can carry a coil of steel weighing 80,000 pounds

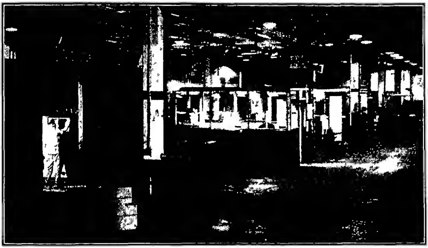
Material-handling devices The first developments in mechanical handling included overhead cranes, jib cranes, and locomotive cranes Overhead cranes still play an important part in material handling Overhead cranes often are used on loading and unloading docks as well as in manufacturing areas where heavy materials are handled These cranes move the materials to monorail conveyors or other conveying devices where the material is moved to storage or point of use

Devices other than the cranes are belt conveyors, roller conveyors, chutes, tubes and pipes, suspended conveyors (Figs 13 7 and 13 8), trucks with various devices for handling material (Fig 13 2), sliding tables or skids, and chain conveyors that pull the item along a track (Fig 13 1)



Courtesy Western Electric Company

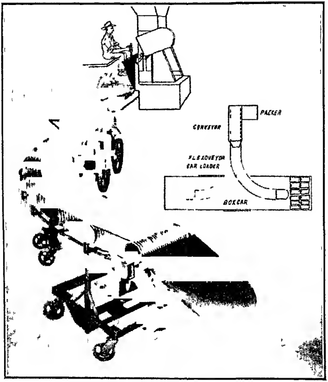
FIG 13 3 Conveyors at Western Electric speed the customer's order on its way to the loading dock



Courtesy, Sharp & Dohme Inc

FIG 13 4 Shipping dock at Sharp & Dohme's modern West Point Warehouse accommodates 7 truck trailers and 6 freight cars simultaneously Facilities are entirely within the building, thus affording protection from the elements for personnel and materials

Mechanical unloading devices, such as those illustrated in Fig 13 9, constitute an important means of saving labor in material handling In the conveying of bulk goods, such as lumber and package goods, such as those in Fig 13 3, standard equipment may be used, the only needed adaptation being the securing of proper lengths Tiering machines (see

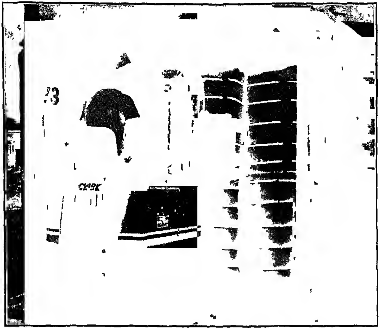


Courtesy Flexoveyor Manufacturing Company

FIG 13 5 A conveyor that may be placed in the freight car

Fig 13 10) and other equipment for handling materials and products in the storeroom are an essential part of such departments An order-filling or stock-replenishing truck (Fig 13 11) is also very helpful Not only do such devices save labor, but also they allow the materials to be stowed to a greater height

Nearness to railroad sidings In heavy manufacturing the selection of a site that allows railroad tracks to be placed through buildings, and railroad freight cars to be spotted at any desired point, from which the material may be handled by cranes, is important Layout of buildings with



Courtesy Clark Equipment Company

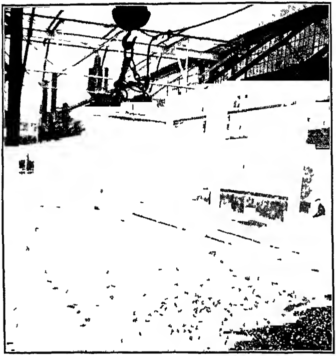
Fig 13 6 Special attachment on industrial truck speeds the loading of unusual bale sizes Other special attachments may be made to this truck

Courtesy Barber Greene Company, Aurora Illinois

Fig 13 7 Power-driven conveyor speeds the unloading of the freight car

due consideration for the permissible curves of railroad tracks is a vital factor in material handling within such plants (see Fig 11 3)

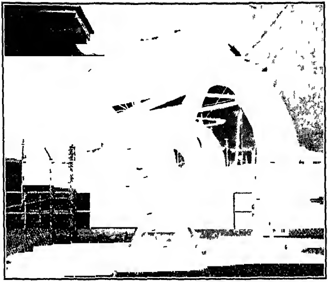
Plant layout and material handling A reciprocal relationship exists between plant layout and material handling The method of handling materials definitely influences the plant layout, and the plant construction



Courtesy, "Automobile Facts"

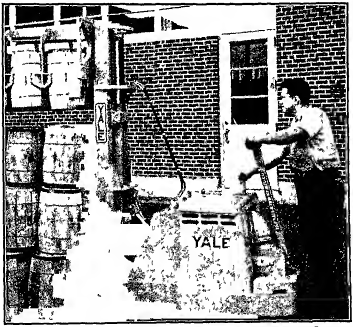
Fig 13 8 The electro-magnet speeds the loading of scrap steel

and layout limit the method of handling materials When materials are moved by hand-operated or power trucks (see Fig 13 11), aisles must be provided for their use When materials are moved by overhead cranes, as is largely the case in the A O Smith automobile-frame plant of Milwaukee, when they are not being moved as a part of the continuous fabricating process on the conveyors, aisles are largely missing, but the overhead space must be unobstructed When materials are moved by pipelines or ducts, as paint is in automobile-body plants (Fig 13 12) and shavings and sawdust are in woodworking plants, provision must be made for these methods of transportation Multi-storied buildings may require elevators or lift conveyors of a different construction than the material-



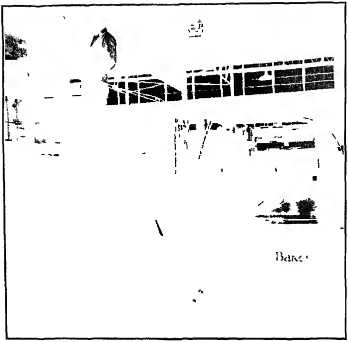
Courtesy Link Belt Company

FIG 13 9 An entire car is being unloaded at one time



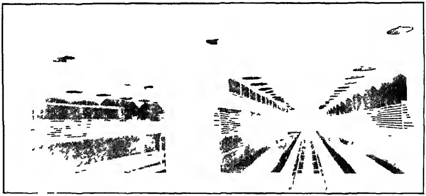
Courtesy, The Yale and Towne Manufacturing Company

FIG 13 10 The mechanically operated, power-driven truck can be used for many purposes, including the stacking of material in tiers



Courtesy Baker Industrial Trucks

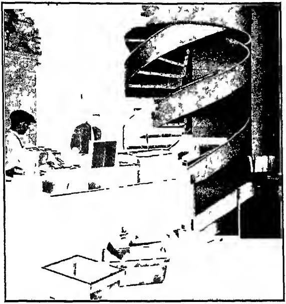
FIG 13 11 Special attachment for the Baker fork truck enables the operator to get at seldom-used stock in hard-to-reach bins



Courtesy, 'Steel

FIG 13 12 Circulating paint to spray booths through pipes illustrates a modern material handling method in automobile-body plants Standardized materials, as well as lower handling costs, result

handling equipment needed in a single-story building in which the same operation is performed Gravity may be utilized in moving materials in a multi-storied building or one built on a sloping grade (see Fig 13 13) Modern material-handling techniques make possible a continuous flow of materials and work in process between buildings and from one floor to another, thus removing restrictions of space and building construction

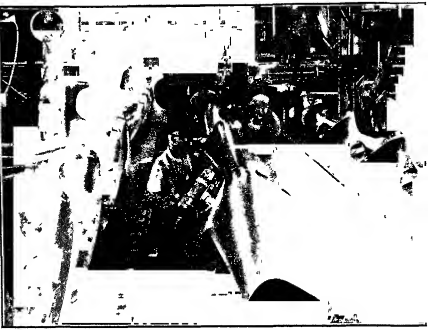


Courtesy Standard Conveyor

Fig 13 13 Standard spiral chute

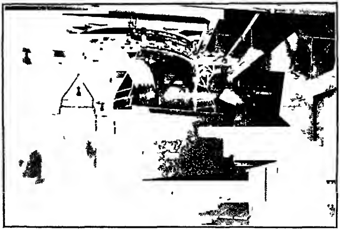
that formerly handicapped the industrial engineer's plans The ideal processing sequence may now be visualized and, by applying known techniques, may be largely realized in spite of serious handicaps of building construction Automation and the semiautomatic plant can be approached by using relatively standardized equipment and connecting the machines to material-handling devices that are operated by electronic controls

Material handling and processes In many modern mass-producing units material handling is an integral part of the process In the cement industry and in flour mills, simple conveying devices have been an essential part of the process for many years The meat-packing industry was one of the first to use mechanical conveyors to support the product while operations were performed upon it Such conveyors change the process from an intermittent to a continuous one and provide for constant utiliza-



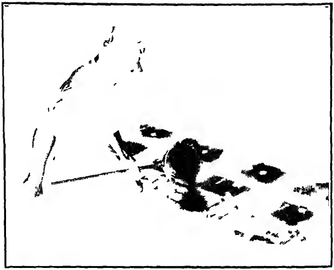
Courtesy, Heintz Manufacturing Company Philadelphia

FIG 13 14 The belt conveyor brings the fenders to the worker and takes them away



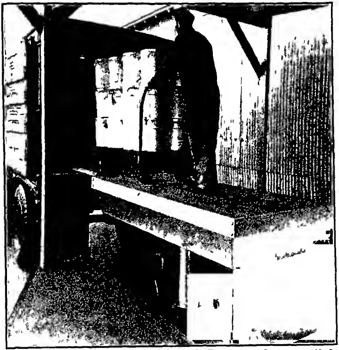
Courtesy, R C Mahon Company

FIG 13 15 Overhead conveyor carrying home-freezer parts from drying oven



Courtesy, General Motors Corporation

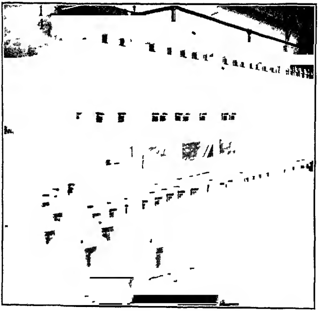
FIG 13 16 The hand ladle weighs as much as 125 pounds



Courtesy, Field Engineering, Jamestown N Y

FIG 13 17 Hydraulic Load o-Matic that will raise or lower material-handling truck to avoid lifting in loading trucks

tion of labor and equipment The gasoline or oil refinery is an outstanding illustration of integrating the manufacturing process with material handling It takes an expert in this industry to know which part of the equipment is transporting the material and which is a part of the process The automotive industry was one of the first to apply mechanical-process conveying of materials on a large and varied scale This industry does



Courtesy The Falk Corporation, Milwaukee

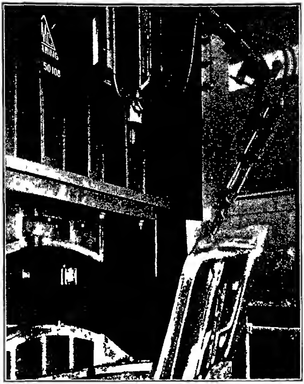
FIG 13 18 Storage is integrated with the material-handling system

its processing, whenever possible, as the material moves (see Fig 13 14) and has applied mechanical handling to all phases of material handling The moving-chain conveyor (Fig 13 15) and its counterparts (used in all mass-producing metal industries) play important roles in determining rates and costs of production in this industry The lowering of prices and consequent enlargement of the market which accompanied the use of process conveyors in the automotive industry is an outstanding development of manufacturing in the twentieth century and has encouraged other industries to endeavor to perfect similar production economies

The mail-order houses in Chicago were the first to apply the principle of material handling to the filling of orders As a matter of fact, material handling is as completely developed in the mail-order business as in manufacturing Many mail-order men claim that the automobile industry

learned some of its techniques from them In the mail-order business orders from the customers are opened by a group of order readers seated along a conveyor

While some foundry moulds are still poured by hand ladles (Fig 13 16) in case of small volume of production, mechanical handling devices (Fig



Courtesy, Richard T Sahlin

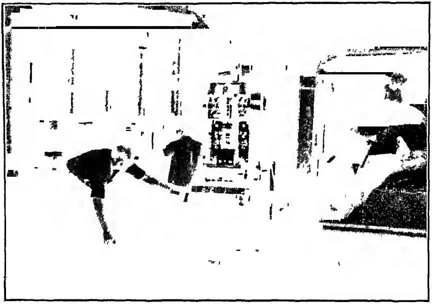
FIG 13 19 The Sahlin "Iron Hand"

9 3) are used extensively in mass-production foundry work The modern air-conditioned foundry is a far cry from those of yesterday or even many of the present-day mechanized operations that are not air conditioned Figure 13 2 shows the handling of steel in the steel industry

Another method of transporting materials is shown by Fig 13 12 This is an ultramodern method of bringing the automobile paint from the paint-storage and mixing room to the spray booth [1] Figures 13 8 and

[1] The principle of piping materials is used extensively in external transportation Gasoline is piped all the way from the oil fields of the South to Chicago Natural gas is also piped from the South to Chicago

13 17 show interesting devices for handling materials Figure 13 18 shows an intriguing method of storing finished parts as an integral part of the material-handling system used by the Falk Corporation A belt conveyor from which fenders are removed for sanding is shown in Fig 13 14 A mechanical arm removing panels from the press, thus protecting the press operator's hands, is an ingenious device (Fig 13 19) With adequate



Courtesy Northwest Metal Products Inc

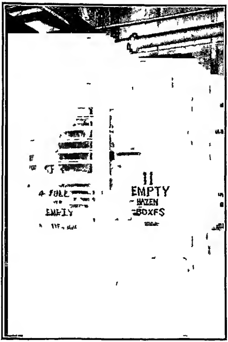
FIG 13 20 It is often more economical to move the press to the work than to move the work to the press

handling equipment (Fig 13 20) plant layout can be adjusted even for relatively short runs Containers for materials often present a substantial handling problem Collapsible tote boxes (Fig 13 21) solve this problem admirably The efficiency of the interplant trucking system can be greatly increased by a communicating system that enables the dispatcher to be in touch with his truckers at all times (Fig 13 22) By properly scheduling trips the transportation department may have trailer loads rather than an individual truck load

Although process conveying is the outstanding feature of material handling today, great strides have been made in other methods of handling materials that have not been mentioned specifically Material handling by modern methods is an important factor in the lowered production costs

of mechanized industry Road building and the entire construction industry make extensive use of mechanical devices for this purpose

Material handling between plants Automobile body manufacturers have equipped freight cars with special devices to facilitate the shipping of parts from a central stamping plant to various assembly units In many



Courtesy Jarvis B Webb Company Detroit

FIG 13 21 The knock down material handling tote box reduces handling costs in returning and storing empties

cases they have found it cheaper to return these cars empty rather than to disassemble the special supports, braces, and clamps that hold the parts in place Special consideration is given to the design of parts that make up the finished product, their transportation from central manufacturing plants to the various assembly plants being kept in mind It is no exaggeration to say that material-handling techniques have definitely influenced plant location in some industries The Ford Motor Company makes extensive use of water transportation between Dearborn and Chicago during the lake-transportation season

Volume and production handling The volume of production of a particular article or type of article is often a controlling factor in the

method adopted for handling material A conveyor may be too expensive to use for handling small volumes, from the standpoint not only of invested capital but also of labor The automatic unloading device will remove the article from the conveyor, but it seldom stores it away Some articles

Courtesy Motorola Inc

FIG 13 22 Two-way radio communication speeds up interplant material handling and increases efficiency

cannot be allowed to pile up on each other Another situation arises when certain items are produced in sufficient volume for mechanical conveyors to be used, but other similar items in the same plant cannot be thus efficiently handled For instance, an automobile company may dip its black fenders in paint by means of a conveyor but dip other colors, not run in sufficient quantities, by hand In one plant automobile seat cushions may be assembled on a moving conveyor, and in another plant owned by the same company these same cushions may be assembled on benches because of the lower volume of production

Material handling and fatigue It is not unusual to find that a particular article can be moved as quickly or even more quickly by manpower than by some mechanical means, yet a mechanical method is used to reduce the physical strain on the worker Sometimes a machine operator obtains his material and returns the finished product to a central place not because these jobs can be done better by him than by mechanical means or by a special trucker, but as a means of breaking the monotony of his work or reducing the fatigue of sitting in one position for too long a period This practice is frequently followed in the clothing industry, such as in making men's clothing

The material-handling engineer Most small companies will not have a material-handling engineer The material-handling engineer is in fact, save in the very large company, an industrial engineer One of the first places that the industrial engineer looks for savings is in the method of handling materials The plant and process engineer give this important item careful attention in their initial plans The present science of engineering has reduced material handling to such a simple subject that it is easy to find a suitable method for handling almost any item Material handling requires careful study of each situation rather than the application of a single method to fit all situations The manufacturer of material-handling equipment usually can combine stock items into a multitude of variations to meet almost any requirement

The industrial engineer or the material-handling engineer should consider the three general factors in approaching a material-handling problem namely, (1) the limitations and advantages of the present system, (2) cost of the present systems compared with other proposed or possible systems, and (3) the future potential of each system that might be considered

The following guide questions should always be in the picture when considering material-handling problems

I Production

1 Are materials delivered from operation to operation without manual handling?

2 Are they placed directly in the machine?

3 If they must be hand fed, are they placed so that the machine operator need make no unnecessary motions?

4 Are materials always delivered as rapidly as they are used?

5 Is setup time at an irreducible minimum? Are tools changed as rapidly as possible? Is material delivered in units large enough to get the longest possible runs per setup?

6 Is the plant laid out primarily for "straight-line" sequence or for process efficiency? If the latter is preferable, would more flexible handling methods permit its adoption?

7 Has manual handling been eliminated from millwright work?

8 Is scrap disposed of without manual handling?

II Receiving and storage

1 Are incoming materials (other than bulk commodities) received in unit packages suitable for power handling?

2 Are they unloaded and delivered to the storeroom without manual handling?

3 Are they stored to the roof whenever desired, without manual handling?

III Packing and shipping

1 Are finished products packed in unit loads suitable for power handling?

2 Are they stored to the roof whenever desired, without manual handling?

3 Are they stowed in outgoing carriers without manual handling?

IV Costs

1 How many man hours are required in handling materials? Are they continuous or concentrated at certain times?

2 Is skilled labor ever required to do ordinary handling work?

3 What proportion of the direct labor payroll is represented by handling?

4 What is the cost per ton-foot of handling materials between departments? Within each department?

5 What is the cost of defective material and spoiled work? What proportion arises from present handling methods?

6 What is the cost of lost time? What proportion arises from present material-handling methods?

7 What are the present compensation rates and to what extent can they be reduced by elimination of handling injuries?

8 What proportion of lost-time accidents are a result of manual handling?

V Handling systems

1 If handling has been mechanized, are the systems in use best adapted for the work?

2 Have they been obsoleted and replaced as rapidly as a net gain in efficiency could thereby be obtained?

3 Have they been supplemented by all improved auxiliary equipment capable of effecting further net gains?

4 Has everything possible been done to assist suppliers to ship in unit packages suitable for power handling?

5 Have customers been informed that their shipments will be made in unit packages on request wherever practical? [2]

[2] *Handbook of Material Handling with Industrial Trucks,* The Electric Industrial Association, Philadelphia, 1950, p 34

14 MACHINES AND EQUIPMENT

Civilization rests on the utilization of machinery The utilization of electricity, the chemical achievements of the present, and the utilization of nuclear energy rest solidly upon man's ability to multiply his efforts through the instrumentality of the machine Watt clearly demonstrated the principle of the steam engine several years before he was able to construct a producing machine, for the very simple reason that there were no machines sufficiently accurate with which to make either the cylinder or the piston The steam engine had to await the development of a boring machine before it could become a reality The same situation exists today The marvels of electricity are dependent upon the ability to make the motor generators that produce the current

Machine tools Machine tools are the machines that make the production machines used in mass production The standard machine tools may also be used in production but they are not efficient for large-scale mass production The basic tools used in making production machines are the lathe, shaper, planer, drill press, milling machine, and more recently the precision grinder It is also true that these same machines are used with special adaptation for production purposes The manufacturers and their workmen are master craftsmen, working with close tolerance and great ingenuity The great Allis-Chalmers Manufacturing Company at Milwaukee produces gigantic production equipment used in industry (Fig 14 1) Its operation would be impossible without the marvelous machine tools with which to work

The plant as a machine Several of the large companies are planning or have established semiautomatic units but the A O Smith Corporation Milwaukee frame plant is still the best-known semiautomatic plant operating primarily as a single machine In fact it is several hundred machines ingeniously synchronized and tied together that operate as a unit Strip steel is unloaded from the freight cars by machinery, is inspected for gauge, width, and length by machinery, and progresses through these many operations with the hand of a man seldom touching it Even the thousands of rivets used daily are inserted in their holes through pneumatic tubes, into which they are fed automatically through a hopper As the frame moves

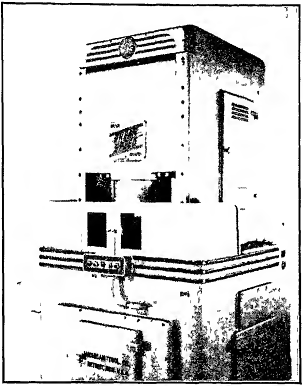
from station to station along the conveyor, the riveting machines move into position, clinch the rivets, and again move back out of the way until the next frame comes into position, when the riveting machines again repeat the cycle It is truly a plant operating as an automatic machine

Courtesy, Allis Chalmers Mfg Company

FIG 14 1 Machining assembled four-section stator yoke in 40-ft boring mill A comparison of the man's height with the work that is being done gives an idea of the size of the machine

Standard equipment Equipment ordinarily includes all apparatus assigned to production centers at which employees work, including workbenches or machines, and all tools, either separate from the machines or fitted into them as particular jobs are to be done Standardization of equipment, like that of tools, is important, not only as a basis for rate setting but also because of the economies of utilizing equipment best suited to its task Standardization of equipment tends to reduce maintenance costs in that the maintenance workmen become more familiar with the peculiarities of standardized machines, and the inventory of repair parts that must be carried for emergencies is reduced This inventory factor is no small item If the machines are too varied, the keeping of repair parts becomes so complicated and costly that an adequate supply of parts will

seldom be on hand. When this situation prevails, breakdowns become very costly, since production will be tied up unnecessarily or overtime has to be paid. Again if adequate repair parts are kept, the total number is much greater for varied machines than for standardized ones.

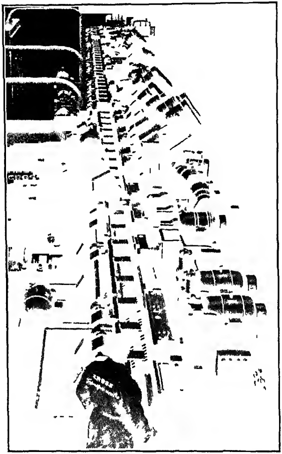


Courtesy Michigan Tool Company

FIG 14 2 High-speed gear shaper. This machine will cut a gear 7″ in 49 seconds.

In so far as the advantages of special-purpose, high-production machines are not sacrificed, economies of production are realized by the use of standardized equipment. Men become accustomed to working with a given type of machine and can be transferred from one to another with relatively little loss in efficiency when the machines are standardized. This fact contributes to flexibility in the use of manpower. There can even be a high degree of standardization in special-purpose machines. It should not be inferred that standardization of equipment requires all machines of the same general type to be alike. As far as practicable, however, all machines performing an identical operation should be alike. A 6-inch

production lathe will be used where the work requires this size, and a 12-inch lathe where the work requires that size. Occasionally a 6-inch operation may be performed on a 12-inch lathe when the other machines are



Courtesy The Cross Company

FIG. 14.3. Cross transfer machine that produces 86 pieces per hour performs 104 operations and has 54 stations.

in use. The matter of *balance in the selection* of equipment is not always easy. At one time a department may be in perfect balance as far as sizes and types of machines are concerned and a year later, when conditions have changed, be out of balance.

When a manufacturer decides to standardize his equipment, he may be faced with the problem of what to do with his present equipment. The

economies gained occasionally will justify standardization even at the cost of selling the old equipment at whatever price it will bring Often this is not the case, yet it does not preclude a definite decision to standardize Instead of replacing at one time all the present machines with the type decided upon for standardization, the desired equipment can be installed

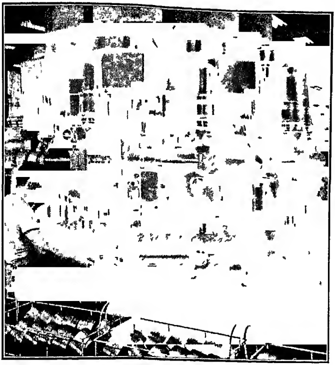


FIG 14 4 This 37-ton machine at Chevrolet's Cleveland plant automatically cuts gear teeth on the inside of the clutch drum, one of the parts of Chevrolet's Powerglide transmission Each part is moved automatically through 10 stations

gradually as the older equipment is worn out It may take some time to complete the standardizing process, but this goal is one toward which good management strives

Special purpose machines vs standard machines "Standard" as it is being used here refers to the general-purpose machines such as the lathe, grinder, planer, shaper, and drill press (It is possible to standardize the production of special-purpose machines) The advantages of the standard or general-purpose machines are

1 Less initial investment in equipment The standard machines usually cost less, largely because they are produced in larger quantities and the cost of engineering is spread over a larger number of machines

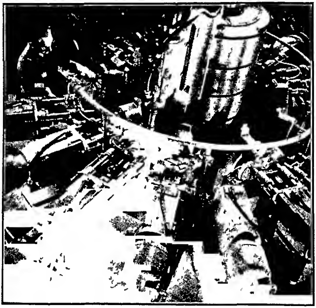
2 Greater flexibility in the range of the work that can be done

3 Possibility of a smaller number of machines being required to meet production needs, as a result of the increased flexibility

4 Greater ability to meet requirements of changes in design of the product or even a complete change in the nature of the product

5 Easier maintenance of balance in the equipment required and less dependence upon mass production

6 Less expensive maintenance, in that repair parts cost less and require less skill to install



Courtesy, General Motors Corporation

FIG 14 5 Automatic 18 station machine drilling holes in reaction flanges for Buick's Dynaflow Drive In 1 hour this machine, operated in a Buick plant of General Motors, handles 106 flanges

Certain conditions must prevail in order to justify the expenditures necessary for installation of special-purpose equipment These conditions are

1 It is necessary that the market for the product be large enough to absorb the output of the special-purpose equipment

2 The product must be well standardized to make use of the special-production machines (see Figs 14 2–14 6)

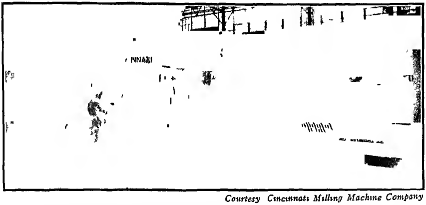
3 Style and technical changes should be infrequent or volume should be sufficiently large to amortize the cost of the equipment in a short time, as in the automobile industry (see Fig 14 4)

4 It is highly desirable that seasonal and cyclical variations in production be reasonably low

5 Sufficient funds must be available to absorb the high fixed-capital investment

Where most of the foregoing conditions prevail, special-purpose equipment has many advantages, among them the following

1 The quality of the product tends to be more uniform
2 Inspection costs are reduced
3 A semiskilled operator usually can be substituted for a more highly skilled man
4 Output per unit of time is greatly increased, thus reducing the direct labor costs
5 Factory floor space is usually less for the same volume of production
6 A reciprocal relationship tends to exist among labor specialization, process specialization, and machine specialization
7 Unit costs tend to be reduced



Courtesy Cincinnati Milling Machine Company

Fig 14 6 A large Cincinnati horizontal broach weighing 90 tons capable of removing metal at the rate of 200 feet per minute when using tungsten carbide cutting tools

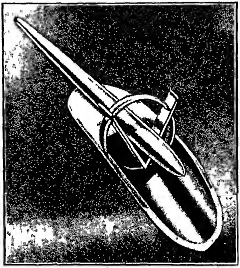
The disadvantages of the standard-purpose machines are essentially the negatives of the advantages of the special-purpose machines, namely, quality is more difficult to obtain, inspection costs are greater, greater skill is required of the worker, output per unit of time is less, and greater floor space is required for the same volume of production

Adapting general-purpose machines to special-purpose requirements Some managers have sought to adapt standard machines to special purposes Probably the best-known instance is the machine built by the A O Smith Corporation of Milwaukee to machine the fittings for the automobile frame The various units of this machine which performed the different drilling, reaming, tapping, and milling operations were built to be interchangeable with each other on the machine base [1] The various operating units of the machine could be assembled in whatever order or sequence

[1] See Franklin E Folts, *Introduction to Industrial Management*, McGraw-Hill, New York, 1938, pp 54–56, also *Bulletin No 210*, A O Smith Corporation, April, 1929, p 13

the individual parts required This was necessary because all the parts did not have the same operations When the adjustments had been made, the machine was automatic The respective operating units were largely general-purpose machines, special bases, however, had to be made for these machines, since their manufacturers did not have standard interchangeable bases

A second method of approaching the economies of special-purpose machines while using general-purpose equipment is to connect the general-



Courtesy Buick Motor Company

FIG 14 7 Die-cast hood ornament

purpose machines by automatic feeds and conveyors and synchronize their operations by some timing device, either mechanical or electrical The machines retain their flexibility, in part at least, and the timing devices and fixtures are essentially the only special features, since the conveyor equipment is frequently adaptable to various machines

Changes influencing machine design The carbide tools will stand up under higher speeds, and the machine builders had to design their machines to stand up under these new speeds The use of higher-alloy steels of greater strength and the accuracy of gear forms have permitted the use of smaller mechanical units of higher speed to fulfill the same functions that previously required larger mechanisms Many manufacturing functions previously requiring machining operations are now being performed by other methods or at least with less demands on the machine tools Foundry castings are being produced closer to size, thus reducing the

amount of metal that has to be removed The same result has been achieved by the improvements in forgings Finishing flat surfaces by coin pressing and producing forms by press work or by surface broaching (Fig 14 6) have changed the machining requirements considerably Grinding,

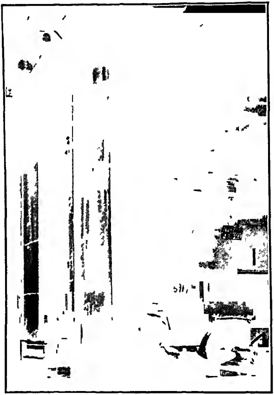
Courtesy Allis Chalmers Manufacturing Company

FIG 14 8 A giant forging press, forging a steam turbine spindle

particularly of rough castings, has greatly reduced the amount of metal that was formerly removed by boring, turning, and facing Die casting of parts not requiring great strength has also greatly reduced machining requirements (see Fig 14 7) With the shorter productive cycle greater emphasis has been placed on the nonproductive functions that are necessary in machine operations In some instances these have become automatic or semiautomatic or have been appreciably reduced by mechanical helps New expenditures, in order to improve quality, will frequently be incurred with the hope of placing the product in a better competitive posi-

tion, even though the equipment may not show any direct manufacturing economies in the immediate present The same situation holds in connection with improving working conditions which involve either safety or health

If special-purpose machines are to be used in the manufacture of a product having a high-style factor, it is customary to require that the ma-



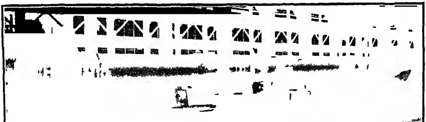
Courtesy Willys Motors Inc Toledo Ohio

FIG 14 9 Modern stamping shop at Willys Motors, Inc, Toledo, Ohio, where Jeep, station wagon, and truck bodies are manufactured

chine pay for itself in a relatively short time, especially during the expected life of the particular style for which it was designed In the automobile industry the special tools, dies, and fixtures are expected to pay for themselves during the life of the current model, which is usually 1 year On the other hand, the more general-purpose equipment is expected to pay for itself during its effective life General-purpose equipment in this sense does not have to be in universal use but must be in general use in

the particular industry For instance, the gigantic press and lathe (Figs 14 8–14 10) are in reality used in relatively few industries, yet their reasonable life expectancy is not less than 10 years Figures 14 11 and 14 12 show two special-purpose machines

Standardization of the work place In machine operations the work place is largely determined by the nature of the machine In tending spinning frames or looms, the work place does not usually include a chair as part of the standard equipment, because the nature of the operation does not give the worker much opportunity for sitting down In many cases, 6, 8, or more looms are attended by a single operator, and the job consists



Courtesy Bethlehem Steel Company Inc

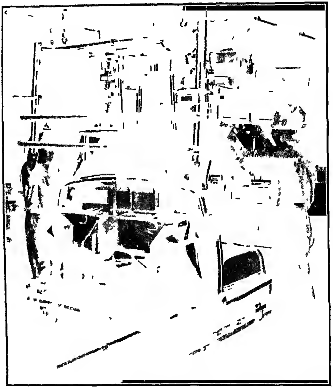
FIG 14 10 Lathe turning 70-foot, 32,000-pound tie rod to be used in a 25,000-ton press

largely of walking from one to another and seeing that everything is running smoothly When standard machines work on products which allow the worker to remain seated, the seating arrangements become a portion of the standard work place

Copy work that is performed by hand is particularly facilitated by a standardization of the fixtures and the work place Each of the small parts that goes into the final assembly has its particular compartment, built to fit These compartments are so arranged that the article may be removed by the left or right hand, depending upon the sequence of operations while it is being assembled, or which hand should carry it to the assembly Motion economy sometimes requires that the small part be in two positions on the bench if it is used in more than one place and is picked up and handled by both hands simultaneously, or possibly in a different sequence

Standardization of equipment other than machines Figure 14 13 shows a standardized tote box used in sending small parts to the assembly line If one part, for instance, a screw of a particular size, is used twice in the assembly, twice the number of this part is provided Much study may be given the arrangement of the divisions of the boxes, so as to entail the least labor in assembling If these boxes are of proper size, they may

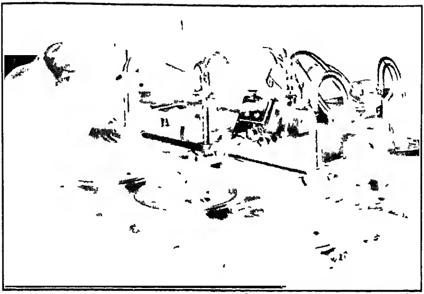
be utilized for a standard number of each part They are very sightly and durable and will nest one into the other when not in use, thus economizing both in floor space and labor of handling



Courtesy, The Studebaker Corporation

FIG 14 11 Workers remove jig after spot welding instrument panel to cowl assembly at the beginning of body assembly line

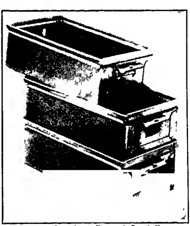
Standardization of the worker's chair (Fig 14 14), particularly of its height, has been given much study In the telephone exchanges the importance of a proper chair has been, perhaps, most conclusively shown Endeavors to improve and speed up service have resulted in close attention being given to the proper type of chair, and the adjustable-height, back-fitted chair that is used in all exchanges today was developed and has become an enormous aid in the handling of the great traffic passing over the large city switchboards The proper height of the work place and the chair depends largely on the nature of the work As a general rule, on heavy work it is desirable to keep the lifting distance small On the other



Courtesy Joseph T Ryerson & Sons Inc

FIG 14 12 Flame cutter cutting several items at once

hand, workers seated on ordinary chairs should not be required to bend too much, or, when the material handled is quite light, it may be profitable to allow the height of workbenches to be determined by the machine-bed level of near-by machines Transfer trucks or tables on wheels of the same height can then be employed, and the bench hands provided with higher chairs

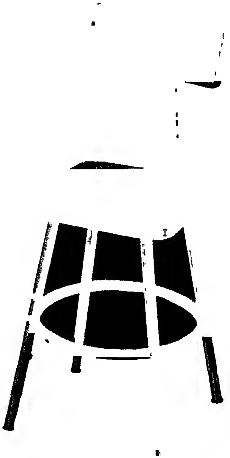


Courtesy, Standard Pressed Steel Company

FIG 14 13 Standard tote boxes

Tool standardization Frederick W Taylor as a part of his contribution to scientific management introduced standardization in cutting tools, shovels, sledge hammers, wheelbarrows, and almost every kind of tool that was readily standardized Frank Gilbreth introduced standard tools in his brick-laying and construction work Taylor showed that workmen, to be most effective in their work, must have a type of shovel peculiarly suited to the material which they are handling His experiments indicated

that a shovel load under ordinary conditions could best be handled if it consisted of about 21 pounds It therefore followed that, if the 21-pound load is to be secured in all cases, a shovel to be used in iron ore must be



Courtesy Royal Metal Manufacturing Company Chicago

FIG 14 14 Complete adjustability to virtually any assembly-line requirement is possible with this Royal Metal industrial chair, which has patented leg extensions as well as a large four-way adjustable backrest

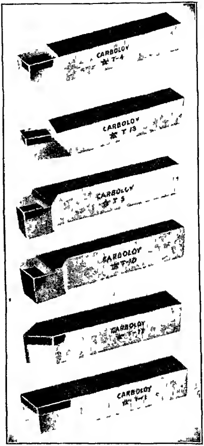
of a different size from one to be used for ordinary dirt, and a shovel to be used in moving coal must be smaller than one used for moving ashes Despite these experiments, to many people in industry a shovel is still a shovel Frequently no particular attempt is made to see that the laboring gang is provided with different types of shovels, based on the material

being worked on or on what is being done with it Nevertheless, great strides have been made in numerous cases, particularly in the contracting business, much attention has been paid to the proper type of shovel

In a work center there are the auxiliary tools used in the preparation of the job and its removal from the machine, and the actual tools used as part of the machine in the performance of the operation To see a high-priced machinist, who operates a machine tool on which the overhead machine rate is also high, spend 15 minutes trying to get a bolt ready to hold his work on a machine is the best possible argument for the standardization of auxiliary tools and for the practice of storing and issuing them to the workman along with the material to be used, as is done with the operating tools Fastening tools in machine-shop work may be given much attention, not only to insure their being available when wanted, but also to see that they are of the right type and in good condition Frequently the preparation time for operations is almost as long as the time required for the operation itself Therefore, proper auxiliary tools, which are usually inexpensive, become real money savers All industries employ auxiliary tools, such as wrenches and screwdrivers, which can be readily standardized

In the past the cutting edge was put on the tool largely by the workman at the job, who was accustomed to grind this edge entirely according to his own whims and prejudices There is a particular shape of tool best adapted to each individual kind of work, and the tool should be ground at certain definite angles which a long series of carefully controlled experiments have shown to be best If all tools are to be ground to these correct angles, the responsibility for grinding them must be taken away from the men in the shop and placed in the hands of a man in the toolroom who has been provided with adequate tool-grinding equipment Figure 14 15 shows the wide variations found in cutting tools used for the same job in one shop, in comparison with a tool for the job properly ground to conform to best practice The composition of cutting tools varies greatly and was completely revolutionized some years ago with the discovery of high-speed steel New inventions are being perfected yearly, and it is not at all uncommon (and is highly desirable) to have a number of types of tool steel in stock in a shop Many shops can still be found in which tools made from a dozen different qualities of steel are used side by side, frequently with little or no means of telling one from another When one realizes that the cutting speed of the best air-hardened steel is, say, 60 feet per minute for a given depth of cut, feed, and quality of metal being cut, whereas with the same shaped tool made from the best carbon tool steel and under the same conditions the cutting speed is only 12 feet per minute, it becomes apparent how necessary is careful attention to the utilization of

the right tool on the right job Some of the special carboloy cutting tools are immeasurably more efficient than the best-known tool steels Each type of cutting tool should be used where it is best suited to the work to be done Carbon-steel tools are still used for many operations, as in accurate finish cuts



Courtesy Carboloy Company Inc

Fig 14 15 Side view of lathe tools Each tool is machine-ground for a specific purpose

15. LIGHTING

Most modern factory buildings are designed to make maximum use of natural illumination, but this is not sufficient for multiple-shift operations or cloudy days. Artificial illumination has been developed to take care of these situations. Scientific research of large electrical manufacturers and of the Illuminating Engineering Society, together with the accumulated experience of plant superintendents, has produced artificial industrial light to meet the most exacting requirements of manufacturing.

Adequate lighting. There is not unanimity of opinion as to what is adequate lighting.[1] Both social and physiological factors enter into the determination of the quantity of light preferred by a given person for a specific reading assignment. If it is the socially accepted custom to have higher lighting values this will be a powerful influence on the choice. The Harvard experiment showed that most people preferred 20 foot-candles[2] falling on the working surface provided that *glare was eliminated,* the *light was distributed evenly,* and the *quality* of the light was neither unpleasant nor uncomfortable. These preferences were indicated without the participants' knowing how many foot-candles were being used. They were exposed to quantities of light ranging from 1 to 100 foot-candles. Although they could see accurately at the higher limits they preferred the range around 20. These people were reading in the library.

The above experiment was reported in 1947. It is possible that a similar experiment would show slightly higher preferences at present because there has been a strong pressure during recent years to provide larger quantities of light for reading. Custom can be changed and preferences are influenced by customs. This experiment showed clearly that the participants could read accurately and with ease with higher amounts of light.

From a physiological standpoint excess quantities of light tend to increase fatigue even though the eye can clearly see the desired item. Of

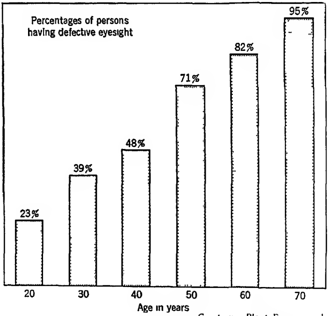
[1] See Alfred H. Holway and Dorothea Jameson, *Good Lighting for People at Work in Reading Rooms and Offices,* Graduate School of Business Administration, Harvard University, Cambridge, 1947, pp. 14–18.

[2] A foot candle is that unit of illumination intensity which is equal to the direct illumination given by a standard candle when placed 1 foot from the object illuminated.

course the factors of glare, even distribution, and quality of the light definitely influence the reaction to a given quantity of light

Advantages of adequate lighting The Illuminating Engineering Society cites the following advantages of good industrial lighting

1 Greater accuracy of workmanship, resulting in an improved quality of product with less spoilage and rework
2 Increased production and decreased costs
3 Better utilization of floor space
4 More easily maintained cleanliness and neatness in the plant
5 Greater ease of seeing especially among older, experienced employees, thus making them more efficient Figure 15 1 shows the distribution of defective vision by age group
6 Less eyestrain among employees
7 Improved morale among employees, resulting in decreased labor turnover
8 Fewer accidents [3]



Courtesy Plant Engineering

FIG 15 1 Chart showing defective vision by age groups

A uniform level of general lighting makes one part of the work place practically as desirable as another, thus enabling the industrial engineer

[3] Illuminating Engineering Society, *Recommended Practice of Industrial Lighting*, p 7 (This pamphlet is not dated, however, it refers to studies made by the Society as late as 1937)

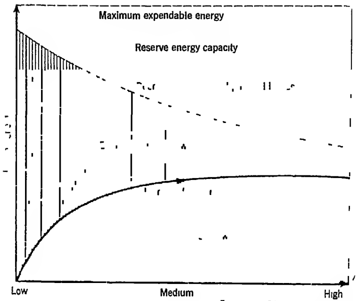
to make most effective use of floor space Good lighting has a direct effect on the cleanliness of the work place and its maintenance in general all-round good condition As a rule, a dark shop is also a dirty shop, a light shop is usually a clean shop Unquestionably an abundance of light in a factory has a desirable psychological effect upon the cheerfulness and well-being of the workers and thus tends to reduce labor turnover

Requirements of artificial illumination The minimum time that a normal industry uses artificial light during the year is 20 per cent of the total working hours To this amount must be added that use which is constant when adequate daylight cannot reach a work place The illumination provided artificially should (1) be of sufficient intensity for the particular operation being performed, (2) be diffused and not glaring, either directly or through reflection, (3) be uniform and not permit marked shadows Absence of glare usually results in reduction or elimination of marked shadows The uniformity of lighting desired depends somewhat upon its application Diffusing of the light source is usually for the purpose of eliminating glare as far as possible

The effects of inadequate or defective lighting Inadequate lighting refers to the presence of less light than is needed for the work Defective lighting refers to some defect in glare, quality, or intensity There can be too much light even though there is no special glare Either defective lighting or inadequate lighting may cause defective work, increased accidents, reduced output, excess eyestrain, fatigue (Fig 15 2), increased absenteeism, increased labor turnover, and at times unrest bordering on low morale "Many factors of poor illumination, such as glare, both direct from the lighting unit and reflected from the work, or dark shadows, hamper seeing and will cause after-images and excessive visual fatigue which are an important contributing cause of industrial accidents Many accidents which are attributed to the individual's carelessness can actually be traced to difficulty of *seeing*" [4] The results of the carefully controlled study of lighting conditions by the Hawthorne Plant of the Western Electric Company in Chicago indicated the difficulties encountered in ascribing increased production solely to one factor, there is little question, however, that defective lighting increases waste, places an unnecessary strain upon employees, and tends to decrease productivity [5] There is adequate evidence to show that proper lighting does exert a powerful influence for increased production This is especially true for persons who have defective eyesight (see Fig 15 2)

[4] See Illuminating Engineering Society, *Recommended Practice of Industrial Lighting*, p 15

[5] M Luckiesh and Frank K Moss, *The Science of Seeing*, Van Nostrand, New York, 1937, p 157



Courtesy Plant Engineering

FIG 15 2 Chart showing intensity of illumination or any improvement in seeing

Sufficiency of light Illumination can be measured in terms of foot-candles by a light meter The output of electric light bulbs is expressed in terms of lumens One lumen will light a surface of 1 square foot to an average intensity of 1 foot-candle The number of lumens required to light a surface to any given illumination is the area of the surface in square feet multiplied by the average foot-candles of illumination desired Table 15 1 lists the number of lumens produced by standard incandescent lamps

Table 15 1 Lumen Output of Incandescent Lamps *

Wattage	Voltage	Lumen Output	Lumens per Watt
25	110 115 120	258	10 0
40		440	11 0
60		762	12 7
100		1530	15 3
200		3400	17 0
500		9800	19 6

* Source of data *Handbook of Interior Design*, Industry Committee on Interior Wiring Design, 1937, p 68

The lamps of higher wattage are more efficient than those of lower wattage In this connection it is also well to note that special bulb shapes or finishes lower the efficiency of lamps For instance, a 40-watt tubular lamp has an output 10 per cent lower than a standard lamp [6] Where medium discrimination of detail is needed, the generally accepted amount of light is 10 to 20 foot-candles, with the tendency toward the upper limit rather than the lower In considering the effect on the eyes of insufficient illumination, it is interesting to observe that the intensity of light on a clear summer day out of doors is from 100 foot-candles in the shade to many times this amount in places where there is no protection Although intensities of 1000 foot-candles are impractical from an electrical and cost standpoint with artificial lighting, 50 to 100 foot-candles are needed if fine work requiring much concentration is to be carried on constantly without undue strain In general, Table 15 2 will serve as a guide to the illumination required for various tasks [7]

Table 15 2 Light Requirements for Various Occupations

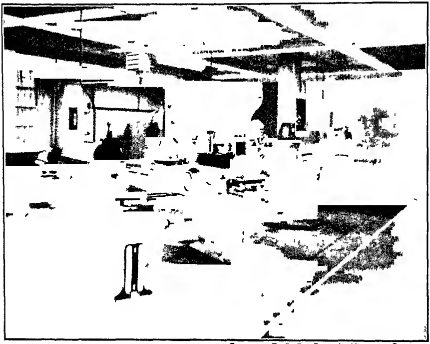
Nature of Occupation	Illumination in Foot-Candles
Where discrimination of detail is not essential	2–5
Handling material of a coarse nature, grinding clay products, rough sorting, coal and ash handling, foundry charging	
Where slight discrimination of detail is essential	5–10
Rough machining, rough assembling, rough bench work, rough forging, grain milling	
Where moderate discrimination of detail is essential	10–20
Medium bench and machine work, fine moulding and core making, newspaper printing	
Where close discrimination of detail is essential	20–30
Tool making, weaving, stitching and trimming	
Where very close discrimination of detail is essential	30–50
Electrotyping, glass cutting, polishing and inspecting, drafting	
Where discrimination of minute detail is essential	50–100
Fine bench and machine work, fine inspecting, typesetting, engraving	

The color of the material worked influences the light requirements Dark and rough surfaces absorb much more and reflect much less light than do smooth, light ones Similarly, the amount of light required will be

[6] *Handbook of Interior Design,* Industry Committee on Interior Wiring Design, 1937, p 39

[7] For detailed information on industrial occupations, see *Handbook of Interior Wiring,* pp 48–51, for office occupations, see W C Brown and Dean M Warren, *Lighting for Seeing in the Office,* General Electric Co , Cleveland, 1936, pp 12–13

affected by the machinery that is used Machinery painted black will absorb a great amount of light Machinery painted gray will not cause undue reflection of light where it is not wanted and at the same time will not absorb nearly so much light Not only does the color of the material



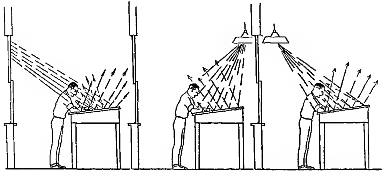
Courtesy E I Du Pont de Nemours Company

FIG 15 3 A Du Pont color conditioned machine shop Machinery is painted in accordance with three dimensional seeing principles Hazards and protective equipment are readily spotted Extreme contrasts in light and dark have been eliminated, and a uniform seeing environment is created by painting walls in Du Pont color conditioning greens Ceiling is white for maximum light reflection Highest standards of safety and efficiency can be maintained

influence the light required, but also does the color of the machines and walls A great deal has been written about the so-called *color dynamics* [8] Undoubtedly the proper selection of colors may contribute to the comfort and contentment of workers Some of the claims of color enthusiasts seem

[8] See Robert B Fetter, "Industrial Application of Color," *Michigan Business Review*, Jan , 1951, pp 20–25, Mathew Luckiesh, *Light and Color in the Work-World,* U S Gutta Percha Paint Co , 1945, Faber Birren, "Color in the Plant," *Factory Management*, Feb , 1945, p 145, also A A Brainer, "Light, Paint, and Safety," *National Safety News*, Feb , 1944, p 18

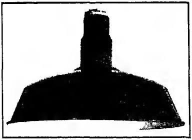
somewhat fantastic On the other hand, a judicious use of color may tend to give the appearance of raising a low ceiling, pushing out the walls in a narrow room, may bring moving parts of moving machinery (Fig 15 3) into focus, and may bring materials and assembly lines into sharp contrast with their environment



Courtesy Edison Lamp Works

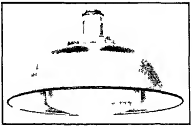
FIG 15 4 Effect of changes in placing light outlets with proper reflectors

Glare and reflectors Glare is of two kinds glare from the source of light, and glare of reflection from bright surfaces Figure 15 4 indicates the manner in which the proper placing of light sources and proper type of reflector will eliminate the glare of reflection Glare arises from improper diffusion, from the source of the light being intrinsically too brilliant (more than about 2½ candles per square inch), and from the angle between the light, the work, and the eye being too small (less than about 30 degrees)



Courtesy Westinghouse Electric and Manufacturing Company

FIG 15 5 RLM Reflector



Courtesy Westinghouse Electric and Manufacturing Company

FIG 15 6 Glassteel Diffuser

Indirect and semiindirect reflectors are not as a rule suited to industrial use except in offices In general, industrial reflectors are of three types or variations of these types (1) the RLM (Reflector and Lamp Manufacturer) (Fig 15 5), (2) the Glassteel Diffuser (Fig 15 6), and (3) the

High-Mounting Reflector, designed for use in narrow interiors, such as craneways to be mounted at least 20 feet above the floor

Types of electric lights The tungsten-filament light is the most popular light in current use, yet the fluorescent light has made rapid strides during

Courtesy Westinghouse Electric and Manufacturing Company and Modern Industry

FIG 15 7 Storage bins use light to best advantage when fixtures are flush with the tops Light paint inside the bins also helps

the past 10 years The tungsten-filament light, when used in proper sizes and with appropriate reflectors, will provide adequate illumination for most purposes Lamps with certain inert gases are generally more efficient than those in which the filament is enclosed in a vacuum Daylight lamps and mercury-vapor lamps are also used for special purposes In purchasing lamps, the cost per lumen produced over the efficient life of the bulb should be the governing consideration in determining the particular make to be bought Daylight bulbs are used where accurate color determination is needed These bulbs are made of a special blue-green glass that ab-

sorbs a part of the reddish rays which are excessive in the usual tungsten-filament lamp. Since the glass in the daylight bulb absorbs approximately one third of the total light emitted by the filament, for efficiency reasons they should not be used except when absolutely necessary. Special reflectors must be used under unusual conditions. Deep bowl reflectors must be used where a deep shielding angle is required to eliminate glare from the lamp filament, for instance, where the mounting height is low, less than 8 feet above the floor. For all elevations up to 20 feet a white bowl bulb is best; above that height clear lamps may be used.

Diffusion. Extreme brilliance improperly diffused only tends to tire the eyes and confuse the vision. Essential in this respect is the avoidance of irritating brilliancy or obscurity, the confusing shadows of obscurity being usually a result of too great brilliance. All portions of the room must be illuminated; there cannot be any dark spots which the eye will see and contrast with the brilliant spots where light falls. The measure of effectiveness of a lighting system is not the brilliance of the source, but the ability of the worker to distinguish clearly and differentiate easily without eyestrain. Adequate diffusion makes possible ease of discernment of any object or portion of an object in any plane, horizontal or vertical (Fig. 15.7). Although large areas of dark shadow must be eliminated, entirely shadowless illumination is not to be desired. Shadowless objects are flat and not normal to the eye. Shadows are influenced by the spacing and the hanging height of the lighting units. A broad, spreading cone of light, such as is produced by the RLM reflector, allows a lower mounting height than reflectors which concentrate light within narrow cones. The Glassteel diffuser encloses the lamp in a white diffusing glass globe, and the porcelain-enameled steel reflector has several slots through which some light is directed to the ceiling, so that there is less contrast between the ceiling and the work place.

Mercury-vapor lamps. Where clear definition of surface is the outstanding requirement, mercury-vapor tube lamps have been used for many years.[9] Special transformers or reactors must be used in connection with the mercury-vapor lamp because of the fluctuation in voltage. A high-intensity mercury-vapor lamp has been developed that utilizes the standard screw base and is much shorter in length than most mercury-vapor lights (see Fig. 15.8). This light bids fair to be an extremely valuable addition to industrial lighting equipment for foundries, spinning mills, small assembly

[9] The mercury vapor lamp emits fewer wavelengths of the visible spectrum than ordinary filament lamps. The eyes need not continually adjust to obtain the proper focus but can confine their efforts to focusing on the reduced number of wavelengths. This results in greater sharpness of vision and less fatigue, hence the clearer definition.

work, composing rooms, and other places where close discrimination is needed Installations have been made combining the new mercury-vapor lamps with the ordinary filament lamps on a basis of equal lumen output from both The result approximates the natural appearance of colors, however, there is still some color emphasis, particularly of the yellows The fluorescent Mazda lamp is an extension of the mercury-vapor principle or other types of "electric discharge" sources Approximately half of the lamp wattage is radiated or accompanies the lumens This characteristic of fluorescent lamps makes them ideal sources for the production of high levels of illumination at relatively low temperatures This light can closely approximate daylight and also be so constructed as to give many different colors The fluorescent light has grown in popularity during the last decade

Courtesy Westinghouse Electric and Manufacturing Company

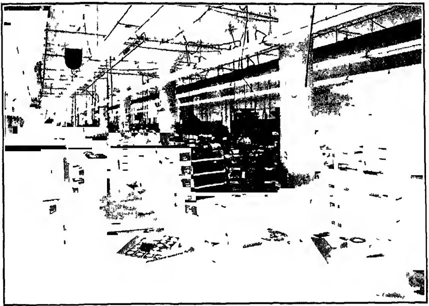
FIG 15 8 A modern mercury-vapor lamp

Arrangements of artificial lights *General illumination* is the method most commonly used Comparatively large units are placed near the ceiling, giving an illumination of approximately equal intensity throughout the whole workroom General lighting, properly spaced, gives an even diffusion of light Illumination up to 50 foot-candles can be satisfactorily obtained from general lighting For tasks requiring more than 50 foot-candles it is usually more economical to supplement the general lighting with local lighting If 20-foot-candle general lighting is sufficient for most of the work in a workroom but a few operations require more, the additional light can more economically be provided by local lighting *Group lighting* or, as it is often called, localized general lighting consists in lighting a particular area by units which are so placed with reference to the work as to illuminate it from the best direction This type of lighting is particularly suitable for large rooms with many machines of the same type performing such operations as spinning, weaving, and buffing *Local lighting* consists of the illumination of a single machine or portion of a machine with light which is specifically directed to the point at which illumination is most needed Such lighting is used on workbenches, lathes, sewing machines, or any class of work where a light may be needed from a nearly horizontal direction or where a high intensity of illumination is required over a small area Drop cords, formerly the standard method of getting local lighting to the desired point, have persisted in some plants until now

Maintenance of lighting equipment Figures 15 9 and 15 10 show a before and after proper arrangement of lights Maintenance of the lighting

Courtesy, The Parker Appliance Company, Cleveland

FIG 15 9 Lighting *before* the improvements in Fig 15 10



Courtesy, The Parker Appliance Company, Cleveland

FIG 15 10 Lighting *after* the improvements See Fig 15 9

system should include a systematic plan for keeping the lamps and reflectors in a clean and otherwise suitable state Proper lighting maintenance includes painting walls and ceilings, cleaning lamps and reflectors, and changing bulbs when their lumen output drops markedly below standard To maintain proper lighting requires accurate knowledge of the lumens at given points at regular intervals The maintenance of the lighting system should be placed definitely in the hands of one member of the organization The size and the structure of the organization will largely determine just where this responsibility should be placed The seven steps for maintaining an efficient lighting system, according to Harris Reinhardt and Willard Allphin, are [10]

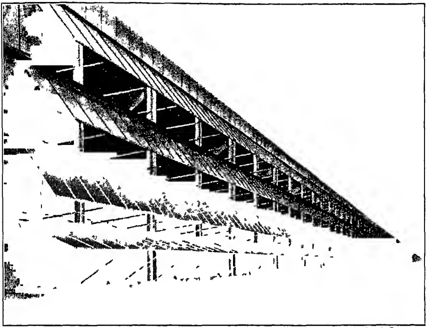
1 Keep walls and ceilings painted in light colors
2 Wash walls and ceilings frequently
3 Check illumination frequently with a light meter, have the meter checked for accuracy once a year
4 Check regularly for dead lamps
5 Maintain voltage at proper level Unduly high or low voltage shortens lamp life and reduces efficiency of your system
6 Keep extra replacement parts on hand
7 Keep fixtures and lamps clean

Use of natural light Newer types of factory buildings have as nearly 100 per cent of their walls constructed of steel as is practicable The development of steel window sashes has greatly increased the amount of daylight that may be admitted These windows may be opened individually or as a group (see Fig 15 11) The amount of natural light that reaches the interior of a factory workroom is dependent on the relationship between the height of the windows and the width of the room unless roof windows are provided to supplement the light from the side walls If windows are on one side of the room, adequate light will be available for a distance twice the height of the windows If windows are on two sides of a room, light will be available for a distance equal to about 3 times the height of the windows Tables are available to show the amount of daylight available at different distances from windows with different heights In multistoried buildings the height of the windows on the lower floors is often made greater than on the upper floors to insure adequate illumination if surrounding structures cut off the light As a general rule, it has been found that poor lighting will result if the ratio of floor space to window space is greater than 6 to 1 In modern "daylight" factories the window space is from one-third to one-fifth as large as the floor space Glass bricks and tile are available for use in side-wall construction and have been used

[10] Harris Reinhardt and William Allphin, "Planned Lighting," *Factory Management and Maintenance*, Vol 110, No 5, May, 1952, p 123

effectively for certain purposes Although the cost is somewhat greater than standard constructions, they have genuine merit in structures where use is made of natural light in combination with mechanically controlled ventilation and temperatures

The top story of a multi-story building or a one-story building often makes use of roof lighting These roof windows are of three types namely,

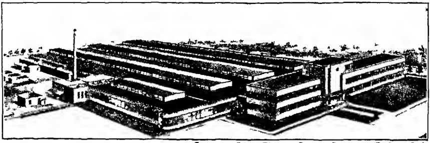


Courtesy Truscon Steel Company

Fig 15 11 A unique provision for ventilation and lighting

skylights, monitor roofs containing either vertical or sloping windows, and sawtooth roofs containing both vertical and sloping windows Skylights usually have the glass placed in nearly a horizontal position and consequently become dirty very easily They therefore do not remain efficient transmitters of light for long unless washed very often Monitor roofs provide nearly ideal daylight conditions for factory interiors (Fig 15 12) It is easy to keep monitor-roof windows clean They can be so placed as to give maximum light at the point midway between the side walls, where light from the wall windows is least Wide monitors, at least one-half the width of the building, are most efficient if single monitors are used In any event the width of the monitor should be not less than twice the height of its windows, nor should the height be more than half its width

Increasing the height of a monitor increases the maximum illumination available, and sloping windows at times increase the light at the point most needed Sawtooth roofs, with the sides containing the windows facing north to secure a minimum of direct light rays, are widely used in natural



Courtesy Penn Electric Switch Company Goshen, Ind

FIG 15 12 Modern factory building with monitor windows

lighting Narrowing the span of the sawtooth or increasing the height of its windows increases the uniformity of light distribution

Table 15 3 Percentage of Light Reflected from Typical Walls and Ceilings *

Surface	Class	Color	Percentage of Light Reflected
Paint	Light	White	81
Paint		Ivory	79
Paint		Cream	74
Caen stone		Cream	69
Paint	Medium	Buff	63
Paint		Light green	63
Paint		Light gray	58
Caen stone		Gray	56
Paint	Dark	Tan	48
Paint		Dark gray	26
Paint		Olive green	17
Paint		Light oak	32
Paint		Dark oak	13
Paint		Mahogany	8
Cement		Natural	25
Brick		Red	13

* Source of data *Westinghouse Illumination Handbook*, Westinghouse Lamp Company, New York, 1934, p 14

Paint and efficiency of lights Interior painting is often neglected in factories long after the point has been reached where poor interior lighting calls for action The percentage of light reflected from the walls and ceilings varies in general with the material and color, as shown in Table 15 3 Although a high gloss on a painted wall reflects more light than a dull finish, its use is frequently unwise on walls which workmen face because of the glare in their eyes

16 AIR CONDITIONING

Air conditioning Air conditioning in its broadest sense is the *control of the physical or chemical qualities of the air or its velocity of movement* for a specific purpose. It includes the following factors taken alone or in any combination: (1) temperature, (2) humidity, (3) foreign substances, and (4) air flow. Air conditioning is relatively new when viewed from the standpoint of present technical knowledge, yet the peoples of ancient Egypt and of the Tigris and Euphrates devised methods of increasing the movement of the air. Air conditioning as we now know it is a development of the present century. The first sale by Dr. Carrier, the founder of air conditioning in the United States, was in 1904 when he sold his first "Apparatus for Treating Air" to the La Crosse National Bank. The apparatus was used to wash air for the ventilating system.[1] For centuries the importance of moisture in the air as a prerequisite for working certain materials has been recognized. The tobacco grower would not attempt to strip his tobacco when the air was dry because of the excessive breaking of the leaves. It was early discovered that the manufacture of cotton thread was simplified when the humidity of the air was fairly high. The first large-scale attempt to control the temperature of air as a matter of human comfort was made in the theaters, where the costs could be spread over a large number of persons.

The purpose of air conditioning To influence favorably the welfare and comfort of employees and customers, the materials and product, and the machinery, equipment, and manufacturing process is the primary purpose of air conditioning. Air conditioning seeks to influence favorably men, materials, and processing as follows:

1 Employees and customers
- 1.1 To protect the health by removing poisonous and obnoxious gases and foreign particles, such as silica dust, lint, soot, and bacteria.
- 1.2 To improve physical comfort by regulating the temperature, humidity, and air flow and by reducing distracting noises, resulting in a favorable attitude or higher morale.

[1] See Margaret Ingels, *Willis Haviland Carrier, Father of Air Conditioning*, Doubleday, New York, 1952, p. 24.

2. Materials
   2.1. To decrease deterioration, as in meats, fruits, vegetables, and certain oils, fats, and chemicals
   2.2. To increase workability, as in tobacco, textiles, and certain plastics
   2.3. To improve the quality of products
3. Equipment and processes
   3.1. To meet the requirements of certain equipment that is sensitive to temperature changes, moisture, and foreign substances in the air
   3.2. To reduce the maintenance cost of equipment
   3.3. To meet the requirements of certain processes, as well as to facilitate inspection

Individual differences in relation to the reaction to air conditioning Individuals differ in their reactions to air flow, temperatures, humidity, and foreign particles, gases, and substances in the air. Man's reactions to the condition of the atmosphere in which he operates are both psychological and physiological, each somewhat influencing the other.[2] An individual may react unfavorably to the presence of certain odors in a room even though there is no detrimental physical action. Some people dislike an odor that others do not object to or perhaps even like. The addition of another, stronger odor which renders the first one unnoticeable but does not eliminate its cause often has the same effect upon the worker as removing the odor. The average-sized man, seated at rest in still air of approximately 70° F with 50 per cent relative humidity, generates about 400 B.t.u.'s per hour. When this same man under similar conditions engages in light, moderately heavy, and heavy work, the British thermal units generated per hour rise to approximately 600, 800, and 1000 respectively. This heat is dissipated through direct contact with the air as *sensible* heat or through the evaporation of perspiration from the skin or the evaporation from the respiratory tract as *latent heat*.

Approximately 3000 cubic feet of air per person per hour, of the right temperature and humidity, should be provided, and the air can be changed from 3 to 5 times an hour to give this amount of air per person without any sensation of draft in the room. If the operation involves hard manual labor, it may be that in the winter months a temperature of 55° F will be sufficient. The ordinary factory workroom can be kept at 65° and be comfortable if the humidity is correct. In the usual type of steam-heating system found in a factory, air which is 40° in temperature on the outside is brought in and heated to 70°. Naturally, this heating dries the air and makes it absorb moisture from anything in the room, particularly from

[2] For an excellent discussion of this subject see F. C. Houghten, Director of the Research Laboratory, American Society of Heating and Ventilating Engineers, "Air Conditioning in Industry," American Management Association *Production Series*, No. 119.

the bodies of the workers This gives rise to the feeling of discomfort and irritation which is frequently found in factory workrooms during the winter months Air at 75° temperature and 20 per cent relative humidity does not feel so warm as air at 68° temperature and 50 per cent relative humidity, or 65° temperature and 60 per cent relative humidity Much of the discomfort of summer temperatures is due to the high humidity, and 70 per cent humidity is probably the maximum which any air should be allowed to reach for normal working conditions There are individual differences within the same group as well as group differences among areas For instance, the people of the Gulf Coast region will demand a comfort zone several degrees higher than the people of Milwaukee [3] Table 16 1 gives the effective temperatures for individuals engaged in sedentary or light muscular activities

Table 16 1 Desirable Inside Conditions in Summer Corresponding to Outside Temperatures * (Occupancy 40 Minutes)

	Inside Air Conditions			
Outside Dry-Bulb, Deg F	Effective Temperature, Deg F	Dry-Bulb Deg F	Wet-Bulb, Deg F	Relative Humidity, Percentage
100	75	83	66	40
	75	80	70	60
95	74	82	64	36
	74	78	70	68
90	73	81	63	36
	73	78	67	56
85	72	80	61	32
	72	77	66	56
80	71	78	61	36
	71	75	66	61

* Copyright, American Society of Heating and Ventilating Engineers Abstracted by permission from Table 2, Chapter 3, *Heating, Ventilating, Air-Conditioning Guide*, 1939, p 66 For persons engaged in active, medium, or heavy muscular work this table is too high The entire field of accurate control of air conditions is highly technical Management should consult specialists in this field before spending large sums of money for an installation

The retarding effects of unfavorable working conditions depend somewhat upon the characteristics of the workers and the nature of the work It is not uncommon to find "white-collar" workers handicapped as much

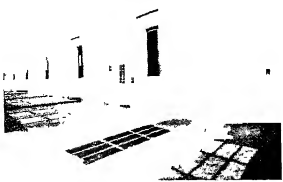
[3] American Society of Heating and Ventilating Engineers, *Heating, Ventilating, Air-Conditioning Guide*, Vol 17, p 66, 1939

as manual workers, if not more, by high temperatures This is especially true if the higher temperatures create conditions unfavorable for their work, such as perspiration interfering with drafting The worker is often not so keenly sensitive to foreign substances in the air as he is to changes in temperature and humidity, yet these substances often are immeasurably more detrimental to his health Certain occupational diseases originate from floating particles in the air Silica is one of the most dangerous dusts

Air conditioning and processing A few industries requiring controlled humidity for best results in processing are spinning and weaving, baking, candy manufacturing, flour milling, precision-tool manufacturing of certain types, food storage, certain types of woodworking, the blast furnace, the tobacco industry, and the rubber industry The need for relatively stable moisture in the air was the original reason why the textile mills of New England located near the foggy seacoast If there is too little humidity in the atmosphere, the yarn becomes very dry in weaving and snaps, thus necessitating frequent stoppage of the loom to knot broken threads If the humidity is too great, it affects the texture of the yarn, causing it to swell unevenly and making a poor grade of goods Modern air conditioning made it possible for the textile mills to move South to take advantage of the favorable economic conditions

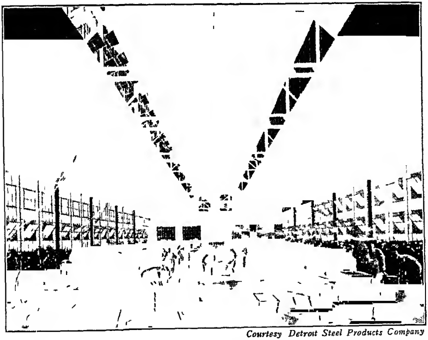
Not only is air conditioning a valuable aid to the working of wood, but also the application of the techniques of air conditioning has greatly hastened the drying of lumber It is no longer necessary to stack it for long periods in the open air to allow it to "season" Kiln drying has largely replaced the air-drying process The Woodward Iron Company of Alabama has applied the principle of air conditioning to control the moisture content of the air used in their blast furnace The air is preheated before being forced under pressure into the furnace This is a further step in standardizing their process of manufacture

Building design and air conditioning It is immeasurably easier to construct a building with air conditioning in mind than to try to air condition an old building (If a central air-conditioning system is planned, the air ducts are built into the walls and columns of the building as integral parts of the structure itself) In this way engineers avoid one of the objections to this system if it is installed after the building is constructed, when it is almost a necessity to place the air ducts overhead in the rooms (Fig 16 1) Proper building construction makes use of natural ventilation which is relied upon to carry off heat from the machines and to provide the fresh air required by the workers Natural ventilation, in spite of the rapid strides made by controlled air conditioning, is still widely used in removing fumes and heat from furnaces and foundries (Fig 16 2) There is usually a prevailing wind in each locality and the greatest natural



Courtesy American Blower Company

FIG 16 1 Distributing ducts for heating system in columns on machine-shop floor, Crown Cork & Seal Company, Baltimore, Md



Courtesy Detroit Steel Products Company

FIG 16 2 Good ventilation in a foundry (Monitor roof, lee windows open with windward side windows closed Side wall windows open)

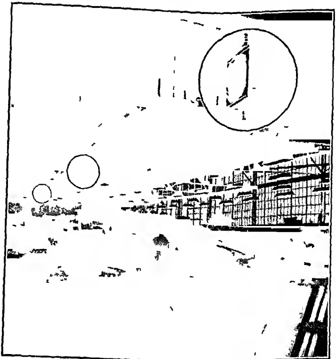
flow of air into a building and out of it is secured when this wind blows at right angles to the walls Maximum advantage of natural ventilation is secured when the windows on the side of the building opposite the direction of the wind are slightly larger than the windows admitting the air Ease of exit of the air facilitates getting air in

If the usual custom is followed of having the sawtooth roof face the north this is not an advantageous roof for ventilation since the prevailing winds are usually from the east or west If the prevailing wind is from the south (an unusual condition), the sawtooth roof is satisfactory The windward side of monitor roofs should be kept closed, and the leeward side opened to get maximum natural ventilation Under these conditions the wind will create suction, drawing the air from inside the building and out the open windows in the monitor (see Fig 16 2) The size of the monitor openings and their height above the inlet openings are the major factors in determining the extent of the air flow

Air-conditioning equipment Heating may be achieved by hot water or steam in radiators or pipes, by unit heaters located at strategic places (Fig 16 3), or by hot air blown from a central station The location of radiators under the windows is efficient from a heating standpoint if radiation is the sole method of distributing the heat Much of the heat from radiators near the windows is likely to be expended in keeping outside cold air from forcing its way in Under such heating conditions humidity control is at best only a makeshift The central heating system draws a fresh air supply into the building and propels it through the building by means of ducts, the outlets of which are properly spaced and so constructed as to prevent the seepage of cold air through the window openings The disadvantage of this system is the presence of the large ducts, usually overhead They obstruct overhead lighting and at times are in the way of overhead cranes and conveyors This system is admirably adapted to filtering the air before distributing it to the workrooms It also lends itself to humidity control by adding the proper amount of moisture at a central control point Many plants which have installed systems of this type have found it very difficult to prevail upon employees to keep the windows closed In fact, some plants have had to go so far as to seal their windows shut, and even then they frequently found in the summer time that employees removed these seals, although theoretically the air conditions within the building were much more satisfactory than those outside Some manufacturers have solved this problem by constructing windowless plants

All the systems discussed are now found in various plants, however, the present tendency is toward the use of unit heaters placed where the heat can be most effectively distributed These unit heaters (Fig 16 3) are constructed of coils, heated by steam, hot water, electricity, or gas, through

which air is forced The air may be brought in from the outside or from a central conditioning station, or it may be recirculated within the room These units may be equipped with air filters, and some of them, for special installations, may be equipped to control humidity These heaters have the advantage of being located so as to circulate the air and thus avoid air stratification, particularly near the ceiling or the floor

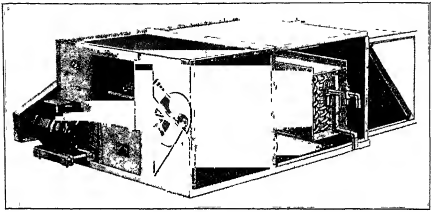


Courtesy, Modine Manufacturing Company, Racine, Wisconsin

FIG 16 3 Unit heaters may be placed where they are needed

Control of humidity Admitting air from the outside during cold weather, either directly through the windows or though central heating stations, causes a drop in the relative humidity when this air is heated Under such conditions satisfactory humidity can be obtained only by adding moisture to the air unless considerable moisture is given off from the manufacturing process, in this event, in the summer, moisture will have to be removed or the air changed rapidly In radiator-heated rooms moisture may be added by placing humidifying saddles on the radiators, but these are not entirely satisfactory The central-heating system using ducts to distribute the air to the workrooms may have connected with it a moisture-

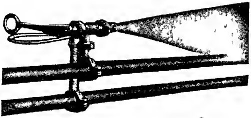
control unit Figure 16 4 illustrates a modern year-round central-heating and air-conditioning unit, which will heat or cool, humidify or dehumidify, clean, and circulate the air All the air or only a portion of it may be taken



Courtesy Young Radiator Company, Racine Wisconsin

Fig 16 4 Cut-away view of an air conditioning unit which provides year-round cooling, heating, humidifying, air filtering, air circulation, and ventilation

from the outside, depending upon conditions It is usually more economical to recirculate a portion of the air Where unit heating is used, but without a central system, it is possible to install unit air filters, humidifiers, and cooling units, either separately or as an integral part of the unit heaters If it is not desired to condition all the air within a plant, the unit air conditioners are cheaper



Courtesy Parks Cramer Company

Fig 16 5 An atomizer humidifier, which relies on compressed air as the atomizing and distributing agency

The problem of adding moisture to the air is relatively simple, but removing it is considerably more difficult When the temperature is lowered, the relative humidity automatically is raised One method of removing moisture is to lower the temperature so far that a good deal of the moisture

is precipitated and the water may be drained off This cold air then is mixed with the warm air in the room to obtain the desired temperature Another method of removing the moisture is to use some chemical such as calcium chloride, which has the characteristic of absorbing moisture from

Courtesy, American Blower Company

Fig 16 6 Air-conditioning system, showing ducts supplying cool air to a foundry

the air This is a simple method for a relatively small area but is not particularly suited for a large plant The separate humidifier (Fig 16 5), which is located in the rooms of many textile mills, is still solving the problems of a large number of such plants satisfactorily However, air-conditioning systems such as those just described can be of benefit to such textile plants, particularly in the summer time, because the humidity can then be either increased or reduced at any given time In the summer proper processing demands a decrease in the humidity rather than an increase

The problem of the bakery is solved by establishing a proof chamber with a temperature of approximately 120° and correct humidity, which is easily controlled This chamber can be separated from the rooms where the workers are

Glass factories and other plants where workers are likely to suffer from intense heat can have the air conditions bettered by means of a ventilating system which includes cold-air ducts, such as those illustrated in Fig 16 6

Courtesy, Air Force Technical Service Command, Dayton, Ohio

FIG 16 7 Each machine is equipped with an exhaust

Removing foreign substances from the air Foreign substances may be removed from the air by

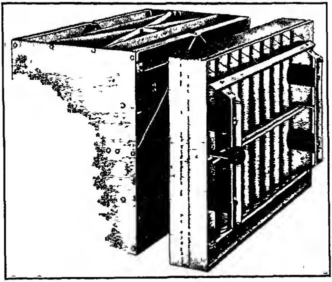
1 Washing—forcing the air through a spray of water This method will remove certain large particles and some gases that are soluble in water

2 Mechanical filtration—passing the air through the filters, which collect particles above a certain size, or removing the cause of the air pollution (Fig 16 7)

3 Electrostatic precipitation

Gases are more readily removed by washing than most other methods Washing air has the advantages of increasing the humidity and lowering the temperature Under certain conditions it may be necessary to dehu-

midify to get the proper humidity For certain conditions this system is entirely satisfactory Mechanical filters are all classified under the following headings throw-aways, those that are used until they become partially clogged and are then discarded, permanent type, those that may be removed and cleaned, replacement fabric type, those that may be removed and have new fabric inserted, and the continuous oil type (automatic) Elec-



Courtesy Westinghouse Electric Corporation

FIG 16 8 The Precipitron (1) A Precipitron cell with ionizer detached to permit a view of the vertical collector plates inside the cell (2) High voltage wire creates an electrostatic field at the front of the Precipitron cell, charging all dust and dirt particles as they enter (3) The charged particles are drawn to and precipitated on the vertical collector plates which are easily cleaned by flushing

trostatic precipitation has been successfully used for years in smokestacks of boilers, smelters, and cement mills The same principle has been adapted to cleaning air for use in work places, hospitals, hotels, and other institutions The Westinghouse Electric Corporation has developed an air-cleaning mechanism known as the Precipitron, which cleans air for commercial purposes to a degree far in excess of anything that has been available (Fig 16 8) The precipitron is of especial value to hospitals and homes where pollens annoy hay-fever victims The initial cost of the mechanism, however, is considerably greater than that of mechanical filters and washing systems Figure 16 9 shows a group of workers steadily at work in a properly air-conditioned shop while others swelter on the outside

While noise is not in reality a phase of air conditioning, it is often as baffling as foreign substances There are a number of acoustical ceilings that greatly reduce noise

Courtesy Rotor Tool Company, Cleveland

FIG 16 9 In a cool and dry room employees work in comfort while others swelter in the same city Also note proper lighting

17 THE MAINTENANCE DEPARTMENT

The importance of the maintenance function Practically every enterprise of any size—hotel, store, school, factory, or utility—has its maintenance department The smooth functioning of the entire operating department is vitally dependent upon the effective operation of the men behind the scenes, the maintenance workers Breakdown of an elevator, conveyor, lighting system, refrigeration system, water system, or of any other vital source of power or other aids usually causes cessation of operations or at least great inconvenience Preventive maintenance is more efficient than remedial maintenance In other words, inspection before a breakdown enables the maintenance engineer to plan repairs and schedule them when the plant is inactive at nights or over week ends, thus preventing a breakdown and disturbance of operations

Figures 17 1 and 17 2 reveal the general nature of the work performed by the maintenance department In actual operations the plant engineer and the maintenance department direct the following activities

1 Keep the buildings and grounds in clean, sanitary condition

2 Make emergency repairs

3 Make routine repairs that are not of an emergency nature

4 Inspect the buildings, equipment, and machines to detect misuse or needed repairs

5 Schedule repairs and renewals in such a manner as to make maximum use of the available manpower and to minimize the disturbance to operations

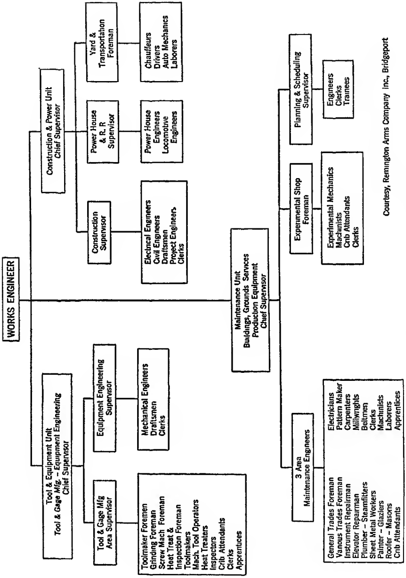
6 Keep records of the various machines and equipment as a guide to the proper use and the selection of new equipment for a given purpose

7 Supervise construction work performed by an outside contractor or do the actual construction with company men (It is often cheaper to have outside specialists do major construction work or even major repairs than to do it with the regular maintenance crew)

8 Sharpen production tools (This function is frequently carried out by someone in the tool crib who operates under the manufacturing department or the production-control department)

9 Maintain cost records that are used by the accounting department and by management

The place of the maintenance department in the organization In most instances the man in charge of maintenance reports to the works



Courtesy, Remington Arms Company Inc., Bridgeport

FIG 17 1 Organization chart of works engineering

manager directly or through other division heads If there is no works manager, the head of maintenance reports to the person who exercises the function of works manager or in a few cases to a vice-president in charge of buildings and equipment, who answers to the president

Figure 17 2 shows the organization of the maintenance function of the Perfection Stove Company It will be observed that maintenance at Per-

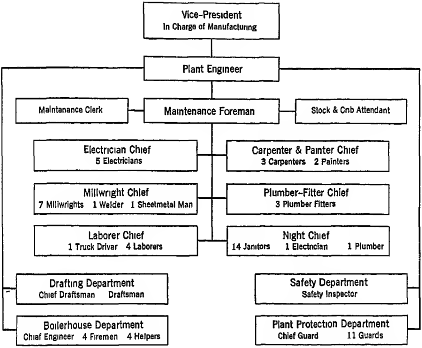


FIG 17 2 Organization of maintenance department of Perfection Stove Company

fection Stove reports to the *plant* engineer, who in turn reports to the vice-president in charge of manufacturing Plant protection, safety, the boiler-house department, and the drafting department also report to the plant engineer In some cases a special planning division of the maintenance department issues all orders for maintenance work (In a few cases this issuing of orders is done by the industrial-engineering department) This scheduling of maintenance orders is similar to the issuing of production orders by the production-planning department in the manufacturing division The industrial-engineering department issues all orders to the maintenance department in much the same manner that production orders are issued to the manufacturing department This procedure makes use of the principle of specialization, separating the "planning" from the

"doing" function "From an over-all viewpoint it has been roughly estimated that the proper employment of highest skills has resulted in (1) saving one-third of available productive maintenance time, (2) increasing by one-half worker efficiency in the maintenance department "[1]

Figure 17 1 shows a high degree of specialization In many plants transportation is not under or associated with the maintenance department or plant engineer except for the repair of equipment In other organizations all internal and external transportation comes under the plant engineer The so-called "yard gang" of common laborers is frequently under the maintenance department Figure 17 3 illustrates a simple maintenance

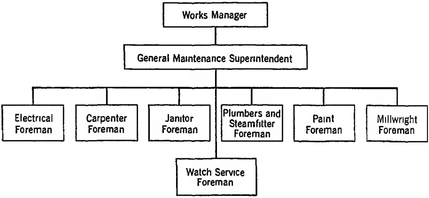


FIG 17 3 Maintenance department in a medium sized plant

department in a medium-sized plant In this case each of the major skills is supervised by a foreman who reports to the general superintendent of maintenance The same organization structure is frequently used in smaller enterprises, with the foremen being working bosses rather than supervisors only In this event the title given to the man heading the maintenance function is usually foreman rather than superintendent or master mechanic

Inspection of buildings and equipment When a pin is sheared and a conveyor stops running, it is not enough to replace the worn pin with one which may be able to carry the load Somewhere else in the system some other item may be out of line, throwing upon the entire system an unnecessary drag which needs to be adjusted Inspection is also an aid in estimating the time required to make the repairs Preventive inspection is designed to reduce hazards and avoid losses that arise from not making repairs before damage is done To be of maximum value preventive inspec-

[1] See R F Bartlett, 'Production Methods Applied to Plant Maintenance," *Factory Management and Maintenance*, Vol 103, No 9, p 133

tion must be scheduled according to the needs of a given situation For instance, an elevator cable does not need to be inspected so often as the exhaust system carrying off the fumes from a duco spray booth In order for inspection to be performed according to the reasonable need of each situation an inspection schedule should be established and carefully followed

Maintenance costs There is probably no area in manufacturing where there is less scientific control of costs than in the maintenance function Sound management procedures call for a maintenance budget somewhat related to the volume of operations When conditions demand the postponement of repairs, there accumulates a deferred expense that may become greater with delay If maintenance of lights is deferred, the cost of current operations may be materially increased Some companies strive to budget maintenance as a percentage of sales [2]

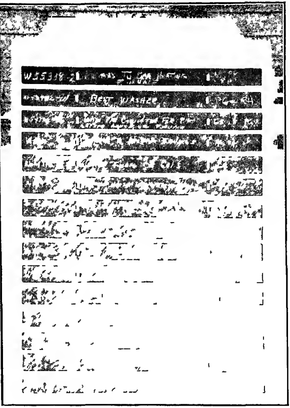
Costs vary from year to year in the same company because of economic conditions both within and without the plant In extremely busy periods, which occasionally last longer than a year, such as during wartime or while there is intense consumer demand for a particular product, repairs may be postponed as long as possible During very slack periods funds may be conserved by postponing repairs, particularly when surplus machines are available Most repairs are made during normal operating conditions or a period of rising production

Operating the maintenance department Close supervision is exceedingly difficult in most maintenance work Maintenance men usually work in small groups or alone Unless some responsible person carefully inspects the work and estimates the time required to do it, the worker may take twice as long as needed without anyone knowing the difference Relatively few standards have been set for this kind of work Most maintenance supervisors have themselves been tradesmen in their respective fields and have no special desire to use scientific techniques that are well established in other phases of manufacturing Most maintenance men are paid on a flat hourly basis and have no particular incentive to do more work than the average The maintenance average is not what the average man can do but what he does in the absence of close supervision and established standards The most effective method to increase the efficiency among maintenance workers is to have each job estimated by a skilled estimator and to pay the workman his regular day rate, with a portion of the time saved as a bonus for finishing the job in less than the required time [3] Such a program entails additional expense for supervision, but the possibility for sav-

[2] See *Factory Management and Maintenance*, "The Cost of Maintenance in Twenty-five Industries," October, 1945

[3] See "Controlling Indirect Labor and Maintenance Costs," American Management Association, *Production Series*, No 194, 1950

ings is great. Each job is scheduled like a production job except for emergencies. Even in an emergency in most cases an estimate can be made by the man in charge of maintenance. Figure 17.4 illustrates a simple control mechanism for scheduling maintenance work. Careful supervision

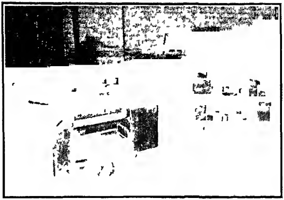


Courtesy New Departure, Division of General Motors

FIG. 17.4. Job priority schedule. As jobs become more urgent they are moved higher up on the priority board. When a job is completed, its panel is removed from the board.

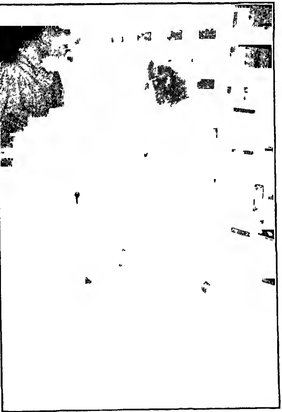
and inspection are necessary when the workers are paid on an incentive system.

Another method of establishing times required for repetitive kinds of maintenance is to time such jobs accurately by a motion and time study man. Still another method is to use past records as a basis. Usually past times taken are discounted by some such figure as 25 per cent to establish the new standards.



Courtesy Manning Maxwell & Moore Inc Bridgeport

FIG 17 5 By providing the maintenance man adequate tools and parts his work is made easier and requires less time



Courtesy General Electric Company

FIG 17 6 Adequate storage of repair parts saves time in maintenance

Still a third method of increasing maintenance efficiency is to provide efficient equipment and tools for the maintenance workers (Figs 17 5–17 9) Of course, efficient use of improved equipment does not follow merely providing the equipment Incentives and proper scheduling are needed with the best available equipment For instance, the maintenance man should "call in" on completing a job rather than to go all the way

Courtesy G H Tennant Company Minneapolis

Fig 17 7 A floor cleaning machine does the work of several men

back to the department for his next assignment He may be needed in the same department where he is working or near by Such simple follow up may save a half hour of travel time Figure 17 10 shows a sample of a valuable aid in getting maintenance work done, a daily instruction card

Maintenance records Regular records should be kept of scheduled inspections, and repairs on each machine An individual record of each machine of any importance is a valuable aid in estimating the relative effectiveness of various machines This record usually gives the date of purchase of the machine and the dates of all major repairs, as well as the nature of these repairs This department also frequently keeps a detailed inventory, as well as a notation of the location of each machine A simple

form (Fig 17 11) is used to authorize work to be done Naturally, for cost purposes the worker charges his time on his daily work report to the charge order number indicated on the work-authorization card Materials used are also charged to the same order number The fundamental rule that applies to all other records applies also to maintenance records, namely,

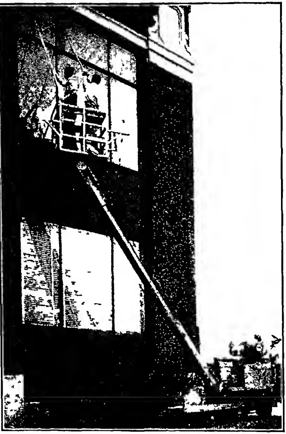
Courtesy New Departure Division of General Motors

FIG 17 8 Aisle lines may be kept properly painted at low cost by using a painting machine

they should be no more elaborate than is necessary to meet the requirements of the situation Inventories of repair parts are frequently kept on the bin cards or on a simple card file in the stockroom

Maintenance equipment Adequate repair parts and standardization of machines facilitates maintenance work Figures 17 6–17 9 show devices for facilitating maintenance work Figure 17 7 illustrates an efficient machine for cleaning floors To avoid unnecessary delays caused by going to the job to find out what is needed and then back to the storeroom for the supplies, a small work stand on wheels similar to that shown in Fig 17 5 is useful Safety ladders reduce accidents, give the worker confidence, and often permit one man to do a job that otherwise would re-

quire two men Where a large number of machines, such as drill presses, are used, an additional machine is frequently kept in reserve to be installed in the place of one needing any major repairs This enables the machine to



Courtesy Caterpillar Tractor Company

FIG 17 9 By using a battery-operated boom crane and a crow's nest window washers at Caterpillar Tractor wash 2,000,000 square feet of windows in about 3 days instead of 3 weeks as by the old method

be repaired in the shops, where the work can be done more efficiently, and also avoids production delays The same situation exists in regard to electric motors and similar equipment

The salvage department The salvage department may or may not be in the maintenance division There may be more materials from the production processes that need to be salvaged than from maintenance In

this event the salvage department may be under production control, purchasing, nonproductive labor, or any other department to which management may wish to assign it By the very nature of maintenance work,

DEPT NO ______ FLOOR E 2 5

DATE MEAS COMPLETED February 27, 1954

WORK UNIT	NO UNITS	TOTAL STD (MINS)	YR FREQ	YR STD (HRS)
100 sq ft	2 9	5	243	20 3
100 sq ft	140 6	211	243	855 0
100 sq ft	50 6	102	243	414 8

from standard times Because standard data are used for estimating only they are rounded off to next highest minute

4

INSTRUCTION CARD

OPERATION Daily Office Cleaning AREA 9th floor all offices on the Mount Vernon Street side

Obtain mobile trash container Go through entire area emptying waste baskets pencil sharpeners ash trays Wipe out ash trays with a damp cloth Wheel trash container to freight elevator Sweep area thoroughly under desks tables etc

Vacuum rugs nightly give special attention under desks

Damp dust tile floors after the buffing operation

Go through entire area each night Dust desks cabinets window sills partitions baseboards and chairs Also dust table in engineering department with a cloth Dust all equipment on desks moving when necessary Wash glass covers on desks with a damp cloth and dry thoroughly Pay special attention to back slats legs and arm rests of chairs when dusting

PRECAUTIONS Do not disarrange papers left on desks Do not spill ink Do not scar or mar furniture

EQUIPMENT Broom dust cards dust cloths dust mop radiator brush feather duster

TIME ALLOWANCE 8 0 hours

RETURN THIS CARD TO GROUP LEADER

DAILY INSTRUCTION CARDS describe jobs for specific areas They help the most inexperienced operator learn quickly

Courtesy Factory Management and Maintenance August 1953 and T M Shea

FIG 17 10 Daily instruction card

there is some material that would become waste if not properly salvaged It is a common sight to see lengths of pipe and joints lying around weeks after a repair or an installation has been made A salvage section usually saves many times its cost This work may be extended to the sorting of

waste from production as well as maintenance Floor sweepings may be put through a magnetic sorting machine to salvage all metal, which may further be sorted to separate the productive material from the scrap

MAINTENANCE DEPARTMENT WORK AUTHORIZATION

Requested by ______________________ Date ____________

Dept ______________ CHARGE ORDER NO ____________

Class of work	WORK AS FOLLOWS
Carp	
Elec	
Mech	
Pipe	
Rig	
Lab	
Mason	
	By ______________________

Courtesy E A Munson Plant Engineer Gould and Eberhardt and "Factory Management and Maintenance"

FIG 17 11 Maintenance department work-authorization slip

metal Packing cases and lumber received with purchased parts frequently have real value when properly salvaged The salvage section frequently works closely with the purchasing department, which may sell certain items not needed in the plant

18 PRELIMINARY CONSIDERATIONS IN MOTION AND TIME STUDY

The need for motion and time studies Frederick Taylor laid the foundation for motion study in his many time studies and experiments Frank and Lillian Gilbreth made extensive use of motion studies and added the time element to get motion and time study [1] Motion and time studies can contribute to the increased efficiency of practically any type of human effort from the performing of an operation in the hospital to the chores on the farm, to the most complicated industrial operation Motion and time studies may be the basis of plant layout as well as the placing of an assembly on a conveyor line Motion and time studies definitely take into consideration the human equation and provide the facts that should promote mutuality of interests between management and workers Since the lack of job standards is one of the most frequent fundamental causes of industrial disputes, plants which have carefully set job standards should have the fewest disputes of this nature, and such disputes as arise are settled promptly and amicably A basis exists on which to settle them, and in these plants facts are used rather than opinion, prejudice, connivance, or force, which has been the more usual basis of settlement Some labor leaders are bitterly opposed while others have asked for job studies and have cooperated with managers in making these studies This situation is far different from that existing just before World War I (1914–1918), when Congress was induced to insert a rider to an appropriation bill forbidding the use of any of the appropriated money for "efficiency" studies Fortunately Congress omitted this stupid rider from the War Department appropriation bill in 1947

Job analysis is used as a basis for writing the *job description* from which the personnel man derives his *job specification* The job description emphasizes the job requirements, whereas the job specification sets forth the requirements sought in the person who is to perform the work The job analysis for the personnel man need not be so detailed or technical as the job analysis used in manufacturing by the industrial engineer The in-

[1] See Wm R Spriegel and Clark E Myers, *The Writings of the Gilbreths*, Richard D Irwin, Homewood, Illinois, 1953, pp 74–75, 77–78

dustrial engineer uses his detailed job analysis as a tool for improving and standardizing methods and working conditions and as a basis for establishing time standards for performing the job

Motion analysis as a basis of improving methods of work Differences of 100 per cent in the time two operators take to do the same task are not at all unusual Usually such operators are using different methods to perform the job If the two workers are analyzed, it will be found that one has discovered a number of short cuts, whereas the other is performing a large number of useless or cumbersome motions The first step in job study is to determine the way in which the best worker performs the job, in order that some of his methods may be imparted to the poorer workers The next step is to try to develop a standard method, which may be an improvement over the best method used up to that time This standard method not only will improve all existing methods of working, but also will include the utilization of standard equipment for the job and will determine and, if possible, eliminate the causes of fatigue incident to the job The third step in improving methods of work is to teach all the employees the new, standardized method Even when deprived of the use of the stop-watch to time operations government arsenals made tremendous improvements by motion analysis

Motion study Frank Gilbreth defined *"motion study as the science of eliminating wastefulness resulting from unnecessary, ill-directed, and inefficient motions The aim of motion study is to find and perpetuate the scheme of least waste methods of labor "* [2] A simple motion study of a job may reveal many losses and useless motions without any consideration of the time element It is not necessary to hold a watch in one's hand to know that a worker who must walk a dozen feet to secure material for his machine or to deposit the finished product of his operation can have his work arranged more effectively General motion study is likely to yield valuable information for the improvement of standards of equipment, and the elimination of useless motions is often one of the best ways of reducing fatigue

The Gilbreths first described their researches in *Motion Study* [8] in 1911 Gilbreth's attention had been forcibly drawn to wasteful operation methods in the brick-laying trade through his connection with the contracting business He had found, for instance, that bricks were dumped in a pile somewhere near the bricklayer by his unskilled assistant and that the bricklayer would take two or three steps over to the pile of bricks, pick

[2] Wm R Spriegel and Clark E Myers, *The Writings of the Gilbreths*, Richard D Irwin, Homewood, Illinois, 1953, p 74

[8] Wm R Spriegel and Clark E Myers, *The Writings of the Gilbreths*, Richard D Irwin, Homewood Illinois, 1953, pp 139–206

up a brick, walk back to the point in the wall where he was going to put it into position, give it several twirls, so that the right side for laying would be upward, and then proceed to put it into place He also found that there were a large number of similar waste motions in connection with the placing of the mortar He developed standard equipment, such as a packet for holding the bricks at a proper level and with the right side already up, and a nonstooping scaffold, which changed in height as the wall was built up He then developed the best methods of utilizing this equipment Gilbreth's studies made little dent upon the building industry, however, largely because of union opposition to increasing efficiency

Gilbreth also applied motion analysis to office procedures If several thousand letters are being mailed a day, as they are in many industries, the saving of only one motion per letter mailed will result in an enormous net gain For instance, in one office the girls folding and sealing the letters formerly were permitted to arrange the work to suit themselves Experiments were conducted to determine in just what order each movement—folding the letter, picking up its inclosure, picking up the envelope, and inserting the letter and its inclosure in the envelope—should be made First attempts were crude, but they immediately doubled the output of the girls Further study resulted in improvements that not only eliminated some motions, but also shortened the distance through which the hands had to move in performing the remaining ones The field of motion-studying office procedures and department-store procedures is a fertile one Marshall Field and Sears, Roebuck employ industrial engineers to aid them in increasing the efficiency of their work Mrs Gilbreth applied motion study to the kitchen and designed her "heart kitchen" in which a mother suffering from heart trouble could cook for her family

Advantages of motion studies Maximum value from motion studies is secured when scientific procedures are used A few of these advantages are as follows

1 Whole methods of performing operations may be changed, and newer and more effective ones found

2 Minor changes in method and in equipment may be devised

3 Data are always secured from which a series of job specifications may be developed

4 Motion study exerts a salutary influence upon the general morale of an organization when the savings made are shared with the employees

Standardization of equipment and operations is a counterpart of motion study Frequently, soon after the start of a study, it becomes apparent that the worker can do no better with the equipment at hand, because he is forced to use a series of nonproductive motions Motion study may lead to such standardization of equipment on an operation that no further steps be-

yond instruction in the proper use of this equipment are needed in teaching workers to perform their jobs When the results of motion study are used for rate-setting purposes, it is imperative that equipment be standardized within reasonable limits For example, if a rate is set from the study of an operator on a properly functioning machine, this same rate should not apply on another machine exactly the same in every detail except that it has 10 per cent more belt slippage Changes made in the methods used on an operation should always be in the direction of straighter, shorter, less time-consuming motions of a kind which become automatic wherever possible

Time study Frank Gilbreth gives Dr Frederick Taylor the credit for inventing time study [4] Gilbreth and his wife Dr Lillian Gilbreth are the real founders of motion and time study as a science Gilbreth defined time study as *the art of recording, analyzing, and synthesizing the time of elements of any operation, usually a manual operation but it has also been extended to mental and machinery operations* We gladly accept Gilbreth's definition without his suggestion emphasizing the manual side To us time study is an accurate analysis of the time required to perform an operation or some part thereof It involves all the features of close observation that are found in motion study, and in addition the time elment is included In modern industry, for purposes of job study all work may be placed under two general headings (1) work done by machines and (2) work done by men Motion study is concerned especially with a study of the work done by the workman with sufficient consideration of the arrangement of machines and their functioning to insure efficient worker production, whereas time study includes a detailed analysis of both "machine time," or the time taken by the machine in doing its share of the work, and "manual time," or the time taken by the workman Manual time will usually be found to be of three general classes (1) the handling of tools used by the workman in connection with the job, (2) the handling of the machine by the workman, and (3) the handling of the material that is being worked upon Time study implies an intense analysis of all three phases of work

Objectives of time studies Time studies are used as the *basis of* "rate setting," or the determination of wage rates, as well as for production control (Time studies should seldom be used for rate setting without being used at the same time to improve methods or conditions

Improvement of methods and conditions is at times the only reason for making time studies Time study provides data invaluable in setting rates that are relatively fair in comparison to each other Time study cannot be expected to set rates that are inherently fair from a cost-of-living or similar

[4] Frank Gilbreth *Primer of Scientific Management* 1914 as reproduced in *The Writings of the Gilbreths*, Richard D Irwin, Homewood, Illinois, 1953, p 74

standard It clearly indicates fair relative rates to be paid on the several jobs studied

Standard or allowed time for a given operation is immeasurably more reliable if based on time studies than if based on previous time taken by the worker in performing the task A good workman on job A takes an interest in his work and in the mastering of his job A poor workman on job B is probably indifferent to his work, or it may be that he has never been properly instructed in the right way of working If the records of poor workmen and good workmen are thrown together throughout a shop as "past performance," the resulting basis of rate setting is likely to be unfair The poor workman, by learning his job or merely by applying himself, may be able under such conditions to double his pay, whereas the good workman, if the job is one where he has always set a high standard will get but a slight wage increase, if any Also, past records are frequently extremely unreliable Jobs of the past were frequently made up of different elements from the present jobs Conditions under which jobs were performed have often been modified by forgotten changes in equipment, which are not taken into consideration as the new rate is set Frequently, since the past records are unreliable, it is necessary to resort to bargaining concerning what past performance was Nothing can be more destructive of the wage fabric of any plant than bargaining over opinions when factual data ought to be available

The preliminary motion and time study The "preliminary study" includes all the work before the recording of the actual observed elementary times It includes the motion study that is made in order that the work may be done in the most effective way It also includes some preliminary time studies taken to check the effectiveness of the motion studies and to determine and record the elements of the task to be timed The observer should spend some time acquainting himself with the work and all conditions which affect it He should observe the conditions which affect it He should observe the conditions under which the raw material is furnished the operator and the facilities which the operator has for disposing of the finished product He should familiarize himself with the quality of the work demanded and the degree of accuracy required He should see that the necessary equipment for the operator effectively to perform his task is provided and at hand, and, if the operation is a machine one, he should see that there is a sufficient supply of power to drive the machinery to best advantage Abnormal conditions should be remedied during this preliminary study Full information should be secured concerning the standards of accomplishment on the job in the past, in order that comparative records may be available after the job has been studied, changed, and timed

The following check list for work simplification taken from a talk before the Time and Motion Study Clinic of the Industrial Management Society (1950) by Herman A Straus, Supervisor of Work Simplification at Servel, Inc , points out things to be considered before making the motion and time studies

Material

1 Can cheaper material be used without impairing quality?
2 Can lighter gauge material be used advantageously? Heavier?
3 Can part be made from off il?
4 Can standard stock parts be purchased?
5 Can some use be found for scrap and rejected parts?
6 Is it received in the most economical length? Size? Weight? Shape? Finish?
7 Is it utilized to the fullest extent?
8 Should we change from 'make to 'buy,' or from "buy" to "make"?

Design

1 Can part be eliminated completely? Partly?
2 Will it help to change tolerances? Specifications?
3 Can it be changed to make fabrication easier? Cheaper? Reduce scrap?

Sequence

1 Is every operation necessary? Can part of it be eliminated?
2 Is every operation performed at the right time? Place? In the right way?
3 Is plant layout the best that can be obtained?
4 Can operations be combined? Separated?
5 Is it economical to use conveyors to move materials?
6 Would change in lot size help?
7 Can inspection be made a part of operation?
8 Can operations be performed while material is in transit?

Tools, gauges, equipment and work place

1 Is the machine the best type for the job? Can it be improved? Is it in good condition?
2 Is it running at the right speed?
3 Would it be economical to make it automatic?
4 Are the machine controls conveniently located for the operator? Are they easy to use? Are they safe? Can they be made automatic?
5 Must the operator continue holding controls after the machine starts for safety's sake or merely because controls are made that way?
6 Is material received and disposed of in suitable containers? Delivered to point of use? Any unnecessary handling?
7 Are tools and materials pre-positioned and in proper sequence for use?
8 Is it necessary to clamp part? If so, are clamps quick-acting?
9 Is it easy to locate parts in the fixture?
10 Can an automatic feed be used?
11 Is disposal automatic?
12 Are tools and fixtures the best that can be designed for the job?
13 Can combination tools be used?
14 Are proper gauges quickly available? Easy to use?

15 Can parts be made in multiple? One at a time? With another part?
16 Is work place satisfactorily illuminated? Heated? Ventilated?
17 Is work place properly laid out?

Operator

1 Can he perform his work either sitting or standing?
2 Does he do unnecessary positioning? Holding? Reaching? Bending? Turning? Walking?
3 Is he properly performing the job? Would further instructions help?
4 Will it help to change to a taller operator? A shorter one? A more dextrous one?
5 Is material handling by operator reduced to a minimum?
6 Are both hands productively occupied?
7 Is the work balanced between the two hands?
8 Can work now being done by the hands be relieved by foot devices? Automatic devices? Holding jigs? Indexing fixtures?
9 Are operators on similar jobs using the same methods?

Selecting the elements to be studied An *element* of an operation may be defined as a single continuous and distinct motion or motions of a worker or machine of relatively short duration, the termination of which is indicated to the observer through sight, sound, or touch In driving a screw, one element consists of placing the screwdriver in position, and another the continuous twisting of the screwdriver while driving the screw A more complex operation is necessarily made up of a correspondingly greater number of elements, but each of them must be continuous and distinct For motion study and the improving of methods in time study, it is important that each separate element, however small, be analyzed In actually recording the times, after the method has been established, it is usually desirable to combine several successive short elements, in order that the watch may be read more easily during the progress of the study It is extremely unwise to try to observe and record elements which follow each other in successions of only a few hundredths of a minute, since an error in the reading of the time on the stop-watch may be as great as or greater than the elapsed time for the element in question For practical purposes an operation should not be broken down into elements any of which are less than about 0 03 to 0 05 minute in duration

In using standard time data (to be discussed later) it is highly important that all of the elements and individual motions in the elements be included The extent of separation of the elements in time studies for rate setting is determined by the nature of the operation and the length of the elements For instance, if the product is standard, not varying from day to day, and is made by repeating the same operation or set of operations, it probably will be wise to study the work from the standpoint of complete jobs, possibly lumping the minor elements together Such time studies

may be termed "operation time studies "[5] If the product varies considerably and is made by a series of operations, the elements of which are also found in other operations on the same or similar products, it will be found extremely undesirable to lump any elements, because the time for each separate element may be desired in order that they may be regrouped to ascertain the time for the other operations Thus, by taking a series of time studies on a number of more or less fundamental operations and elements in a shop, it may be possible to arrange and combine data in such a manner that the proper time of performance may be secured for practically every job that the shop may perform, without taking new studies Such time studies may be called "fundamental element time studies," and in them the time for each separate element is carefully secured After the elements have been determined, they are noted in the space provided for them on the observation sheet An examination of Fig 19 2, p 19 3, shows that the various elements running across the top of the page under the heading "cycle or line number" comprise distinct items The standard method of performing the operation is thus determined, with all discernible improvements in equipment and method already accomplished, or a note is made to provide for further improvement at a later date

Therbligs Frank Gilbreth's works were being used by others without giving him credit At the suggestion of his wife, Dr Lillian Gilbreth, he used the name *therblig* (*Gilbreth* spelled backwards) to represent the basic elemental motions that are common to all work This name was generally adopted by writers in the field Whenever it is used the Gilbreths are recognized Gilbreth listed 17 therbligs (see Fig 19 7, p 19 11, for symbols) Professor Barnes, whose list is used below, has classified 18 therbligs Other investigators have used a different number of therbligs The therblig is supposed to represent an elemental motion The student should not infer that all motion and time study men in practice actually use therbligs They are valuable for detailed studies, the data from which may be used in other studies The most common ones in use are as follows

1 *Search*[6] (Sh) refers to that part of the operation cycle during which the hands or eyes are trying to locate the object

2 *Find* (F) occurs at the end of *search* and is in reality more of a mental reaction than a bodily movement

3 *Select* (St) represents the actual sorting out of one object from among two or more objects (The three therbligs *search*, *find* and *select* are frequently combined into the one therblig *select*)

[5] The term 'operation time studies" is also applied to studies in which the over-all operation times are taken without breaking them down into their elements

[6] See Ralph M Barnes *Motion and Time Study*, John Wiley & Sons, New York, 1949, pp 95–100, 149–179, for a detailed description of therbligs and their use

4 *Grasp* (G) involves the actual taking hold of the object (In practice *select* and *grasp* are frequently combined)

5 *Transport loaded* (T L) refers to the actual moving of the object from one place to another

6 *Position* (P) consists in adjusting the object so that it will be ready to fit into the location for which it is intended

7 *Assemble* (A) begins as the object starts to move into its place in the assembly

8 *Use* (U) is the actual manipulating of the tool or apparatus for the achievement of the purpose intended

9 *Disassemble* (D A) is the separating of one object from another

10 *Inspect* (I) is the act of checking to see if the work meets predetermined standards

11 *Pre-position* (P P) refers to the placing of the tool or object in such a position that it will be ready for use when needed This therblig eliminates the therblig *position*

12 *Release load* (R L) is the actual "letting go" of the object

13 *Transport empty* (T E) is the moving of the hand empty, either in reaching for an object or returning to a given position after the therblig *release load* (R L)

14 *Rest* (R) is a delay factor provided to enable the worker to recover from the fatigue arising from his work

15 *Unavoidable delay* (U D) arises either from an interruption in processing or a situation in which one part of the body is prevented from working by another body member

16 *Avoidable delay* (A D) arises from any delay over which the operator has control

17 *Plan* (P) arises from the mental processes involved in making a decision of how to proceed or what to do next

18 *Hold* (H) signifies the retention of an object after the therblig *grasp*, during which time there is no movement of the object Gilbreth included the therblig *hold* in his therblig *grasp*

The standard symbols and colors for therbligs are shown by the chart on p 19 11 (Fig 19 7)

Qualifications of the motion and time study man The motion and time study observer should possess an analytical mind and be able to detect small variations in the process from time to time He must also have enough knowledge of the machine and process to be able to perceive and try out slight mechanical changes which may be called to his attention during his studies In addition to the technical qualifications a job-study observer must have confidence in the men with whom he is working and must be able to gain their confidence, as well as that of the superintendent and the foremen In devising a standard method to perform a job, many possibilities will have to be investigated, and the worker's cooperation is essential, particularly if he has a fund of knowledge based on past experience with the job It is presumed that the observer possesses the technical qualifications, because the more he knows about the operation, the better able he will be to suggest alternative methods On the other

hand, if he has gained the confidence of the whole department in which he is working, he has performed a large portion of his task Securing confidence is necessary for the following reasons

1 The full cooperation of everyone is needed for the best results

2 Secrecy is impossible, even if it should otherwise be desirable The workmen will hear rumors which will be worse than the facts, whatever they may be, and these rumors will be "confirmed" when their rates are changed as a result of the observations that they knew of only by hearsay

3 In order for the time study to be of maximum value, it is necessary that shop information which has been collected by the foreman and workmen over a period of years shall be at the disposal of the time-study man

Phil Carroll, a prominent professional practitioner in motion and time study, asked a group of specialists in the field to appraise the influence of (1) ability, (2) desire, and (3) human relations upon success in motion and time study work The responses of 77 men were ability 29%, desire 24%, and human relations 47% These figures point out the importance of the human relations factor in motion and time study work Of course it would be erroneous to assume that a man need not be technically proficient It merely means that a technically proficient man will find that his human relations job provides him his greatest challenge

Selecting the operator to be studied Motion and time study men usually select the skilled man,* rather than the average man, because allowances will be made in computing time values which will be fair to the average man The skilled man is better for observation purposes His motions are uniform, he works steadily, and he is apt to use the best methods and adapt himself more readily to new ones The erratic work of unskilled employees throws into the calculations all sorts of variables, which have to be ruled out as the computations are made The experienced time-study observer, acquainted with the work, soon learns when a skilled operator is working at a normal rate, but he has more difficulty in making this discovery concerning an unskilled operator The observer is able to get a skilled man to improve his production if need be, or, on the other hand, is able to recognize unusual ability or excessively rapid movements which cannot be maintained without physical exhaustion Such cases are properly discounted by the observer, for *the desired time standard is one that can be used by persons following instructions and working at a reasonable pace that can be kept up from day to day without undue*

* Some observers select a "so-called" average worker to be studied Some unions insist on the timing of the average worker Frequently it is difficult to decide who is an average worker If the agreed upon "average" worker is also a skilled worker he is satisfactory, however if he is not skilled a study made on him would not be desirable

exertion. Another reason for the selection of the skilled man is that in setting performance standards, as in setting any other standard, the best-known method at the time for the given conditions should be selected as the standard. On work on which large numbers of persons are engaged and which is to last for some time, more than one operator should be studied in order that the resulting rates may represent standard performance.

In observing group work (that is, work in which the operation includes more than one worker), a different approach is required in such work as assembling since the speed of the group is limited largely by the speed of the slowest member. Therefore, in such cases it is necessary to consider carefully the personnel of the group to determine whether it is composed entirely of skilled employees, and, if not, whether such a group can be assembled. Attention should also be given to the operations assigned each member of the group working on the assembly. It is sometimes found that an employee who is thought to be slow and thus holding back his group is in fact doing more work than is justly his share. A rearrangement of his tasks may shift a part of his work to another and thus increase the efficiency of his group. If an individual operator is slower than his group, he should be transferred if possible. If he is kept in the group for some reason, an adjustment of tasks may still result in greater efficiency. When others are carrying a part of the work for a given operator, earnings should be adjusted accordingly.

There are two classes of group work, and the necessary skill of all members of the group will vary with the class into which the particular work falls. These classes are (1) work in which the main part of the operation is performed by one employee, who is merely assisted by other employees, and (2) work in which several employees work together, each doing his portion of the job sequence. An illustration of the first type of group work is the laying of cloth in a clothing factory. Although the operation is comparatively simple, to handle each type properly demands a certain knowledge of the tailoring trade and the peculiarities of cloth. A cloth which has a very smooth finish may be easily disarranged in pulling one layer over the next, whereas another which has a heavy nap may tend to stick and must be handled in an entirely different manner. One employee cannot do the work alone because of the width of the cloth which requires that he have an assistant working on the opposite side of the table. The assistant, of course, must learn how to handle the cloth but he does not require so much detailed knowledge and hence will not need to be so skilled an employee as the one in charge of the operation. An example of the second type of group operation is one wherein the worker is limited by the speed of another, and yet all are doing work of approximately equal importance.

What operations should be studied? On the assumption that motion and time studies are being introduced for the first time, the neck-of-the-bottle operations, the most important in any plant, should be studied first Even small results achieved there will unquestionably bring large profits with them It may take longer to get results, but, if the continuation of a job-study program is to be dependent on quick results, the program should never be undertaken If the program has been well established, the needs of current operations may dictate what studies to make For instance, if a new job is going into production it will require study as a basis of wage-rate setting It is highly important not to take time studies when the conditions are not standard Under such conditions the studies themselves will fall into disrepute, particularly if the workmen know the loopholes in the standards being set Such a "standard" time will be worthless, since it is based on variables Another danger is to spend time in making "stunt" time studies There is always a tendency to spend effort in reducing the time of performance on operations which evidently are poorly carried on In such cases statistics of percentages of time reduction will be interesting, but, if the operation is an unimportant one, as it is likely to be if huge reductions in performance time are possible, the profit from the study will be small

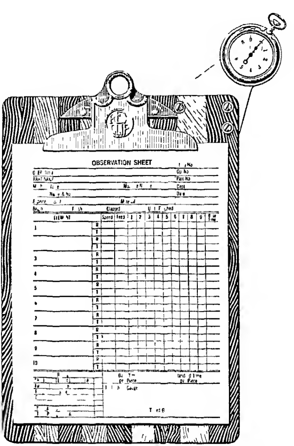
19 TAKING TIME STUDIES

Time-study equipment. Time-study equipment usually includes a decimal stop-watch, an observation sheet on which the watch readings are recorded as the study progresses, and a board for holding the watch and observation sheet (see Fig. 19.1). Other items frequently used by many time-study men include the tachometer, or revolution counter for measuring machine spindle speeds, and mechanical calculating devices, such as the slide rule and adding machine, or comptometer. Certain timing devices other than the stop-watch have been developed which have limited applications under special conditions, including the microchronometer, the wink counter, the Marsto-Chron, and the kymograph. Of course, if the more recently developed *Methods-Time Measurement* (MTM) is used, the standard time data sheets may be substituted for the stop-watch. However, some companies that use MTM also time the jobs to gain acceptance of the times established (the psychological appeal to the worker).

The time-study sheet. Figures 19.2 and 19.3 portray the front of illustrative time-study sheets and a stop-watch. Figure 19.2 is selected because it is a composite of the best features of many observation sheets. Its adoption by many companies in a wide variety of industries is indicative of its adaptability to almost any type of practical time-study work. In any event, the observation sheet should have space for a full description of the operation and the conditions under which it was taken, with the conditions illustrated, if practicable, space for entering the times of the various elements as they are observed, and a series of columns concerning the time of each element and the proper time for the whole operation.

The stop-watch. There are two types of stop-watches commonly used in taking time studies, namely, the decimal minute and the decimal hour watches. In both types the principal dial is divided into 100 divisions, and the smaller dial into 30 divisions. The small hand moves one division on the small dial while the large hand makes one complete revolution. Thus, the watch cycle includes 30 complete revolutions of the large sweep hand. On the decimal minute watch the sweep hand makes 1 revolution per minute, or 60 revolutions per hour, but, since the small hand accumulates 30 revolutions of the large hand, the watch has a total cycle of 30

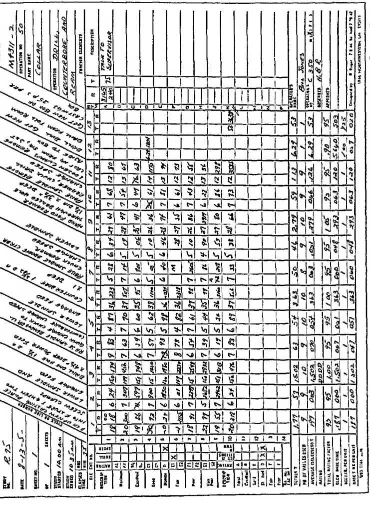
minutes or one-half an hour. With 100 divisions on the dial, each division represents 0.01 minute, and this is the smallest time value which can be read with practical accuracy on the decimal minute watch. The decimal



Courtesy Ralph M. Barnes, "Motion and Time Study," John Wiley & Sons

FIG. 19.1. Stop watch study board with observation sheet for recording data taken by the continuous method.

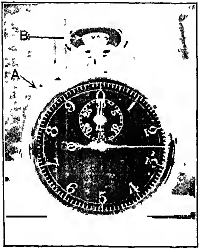
hour watch has the same number of divisions on each dial as the decimal minute watch, but the large hand makes 100 revolutions per hour instead of 60 as on the minute watch. Since the large dial has 100 divisions, and the hand makes one revolution in 0.01 hour, each division represents a time value of 0.01 $\times$ 0.01 or 0.0001 hour. This is the smallest time value which can be read with practical accuracy on the decimal hour watch. The small hand accumulates 30 revolutions of the large hand, or 0.30 hour



Courtesy H Barrett Rogers and Claude George

FIG 19 2 Observation side of time-study sheet For convenience, the watch readings shown in the *R* columns may be recorded in pencil The subtracted times shown in the *T* columns, as well as all other calculations and identification data, should be recorded in ink for permanency

The cycle of the decimal hour watch is only 0.30×60 or 18 minutes, instead of 30 minutes as on the decimal minute watch. Decimal hours are more convenient for cost-accounting and payroll purposes because wage rates usually are considered as "hourly" rates, but the average worker has more difficulty in comprehending time values expressed in decimal fractions of an hour than those expressed in minutes. Furthermore, machine speeds customarily are rated in terms of minutes, such as revolutions per minute or strokes per minute. The decimal minute watch therefore is more widely used.



Courtesy Ralph M. Barnes, Motion and Time Study, John Wiley & Sons

FIG. 19.3. Stop-watch.

The principal advantage of the stop-watch is the convenience in starting and stopping the hands and resetting them back to a zero starting point. In addition, the outer dial usually is divided into 100 divisions so that fractions of revolutions of the hand can be added more easily as decimals. On the decimal minute stop-watch shown in Fig. 19.3 the hands may be started or stopped, without resetting, by moving slide A. Pressure on the stem B resets both hands back to zero, whether the watch is running or has been stopped. If the hands have not been stopped by the slide A, they will remain at zero as long as the stem B is held down but will start as soon as the pressure is released. It is this case of resetting the hands to zero and starting them again by a quick pressure and release on the stem that makes "snap-back" readings possible. For all but the most rapid elements, or for micromotion studies, the stop-watch remains the most practical timing device for most time-study work. Perfectly satisfactory time studies can be made with any ordinary pocket or wrist watch, especially if it has a sweep second hand, but the times necessarily will be recorded in minutes and seconds, and extra calculations will be necessary to convert the seconds into minutes.

The motion-picture camera. Frank B. Gilbreth utilized the motion-picture camera in determining time values, by placing a special clock or microchronometer (Fig. 19.4) in the field of vision and obtained the "therblig times" from an analysis of the film. Modern motion-picture cameras used in photographing operations are frequently equipped with

electric motors that operate the camera at constant speeds By counting the frames that cover a particular operation, the exact time elapsing may be determined Thus, the moving picture not only becomes a permanent record of the operation but a timing device as well It provides an accurate record of everything that transpires It is possible to restudy the operations scientifically without the distraction of production going on at the same time The film may be run at slow speeds and thus a particular motion may be analyzed in detail Some operators are so fast that the human eye can scarcely detect their movements By the use of the motion picture their motions may be slowed down for analysis, and exact time values determined For instance, it is possible to determine the exact time required for an operator to shift his eye and focus on an object This would be practically impossible by any known technique other than motion-picture analysis Waste motions may be studied not only by the observer but also by the operator himself The motion picture thus becomes not only an excellent device for correction but also a valuable aid in instruction

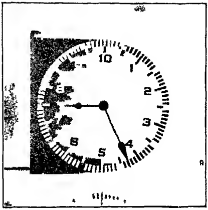


FIG 19 4 Microchronometer

The standard time data used in MTM is claimed (and justly so) to be more accurate than times derived from stop-watch time studies because these MTM data are derived from motion pictures They can be read at leisure and do not have the errors inherent in reading the stop-watch The use of motion pictures in time and motion analysis is somewhat expensive but by no means prohibitive The expense increases proportionately to the length of the operation cycle studied Relatively few time-study men are trained in the use of the motion-picture technique

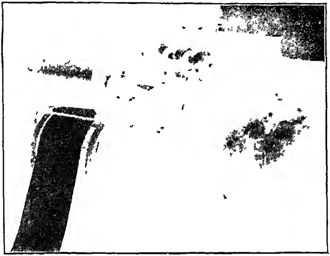
The "wink-counter" The microchronometer dial must be rather large for the divisions to be seen easily in the moving pictures and takes up a large portion of the picture, furthermore, the operator constantly is aware of the large clock, particularly of its rapidly moving hands, and the psychological effect is undesirable To avoid some of these difficulties, Professor David B Porter of New York University devised a "wink counter" It is an electric clock mounted in a relatively small box and having three revolving discs with large numerals on the edges, it is read like an automobile speedometer It can be read accurately to 0 005 minute, and for

use in motion pictures a revolving helix permits still smaller readings. The device is small, requiring less than one quarter as much space in the picture as the microchronometer, yet the large numerals make it easy to read. Without the fast-moving hands it is less annoying to the operator.

The Marsto-Chron. While using a stop-watch the observer not only must watch the operation, but he also must read the watch and then look at the paper to record the watch reading in the proper place. To permit the observer to focus his attention on the operation, the Marsto Instrument Company, Waban, Massachusetts, has developed the Marsto-Chron. The beginning and end of the operation are recorded by pressing two keys, and the end of each element is recorded by pressing one key. Pressure on either key depresses a type bar, making an instantaneous mark on a narrow crosswise motor-driven tape which moves at the rate of 10 or 20 inches per minute, depending upon the motor drive used. Time values of 0.01 minute or less can be recorded with considerable accuracy, and the observer has no watch to read or readings to record at the time of taking the study. On very short, highly repetitive operations and those in which the element sequence never changes during successive cycles, the time values can be identified with the proper elements according to the sequence of occurrence on the tape, and the values can be measured by sliding the tape under transparent scale, calibrated in minutes to correspond with the running speed of the tape. If minor interruptions occur during the cycle or if the element sequence changes, however, it is practically impossible to identify the element to which a certain time value belongs. In its practical application, therefore, the Marsto-Chron is limited to use on short cycles of not more than perhaps 10 or 12 elements, and to operations in which the elements are less than about 0.05 minute.

Barnes' kymograph. Dr. Ralph Barnes of the University of California, Los Angeles, developed his kymograph (Fig. 19.5). It uses a motor-driven tape, such as adding-machine tape. Three or four (or possibly more) markers rest on the tape, making continuous lines lengthwise of the tape. The pencils are controlled by solenoids which, when actuated, cause the pencils to move a short distance crosswise of the tape, thereby making jogs in the pencil lines. Distances between the jogs indicate the time values, and a considerable variety of elements can be identified by the various combinations of the jogged lines. The solenoids are actuated electrically by photocells, push buttons, or other contracting devices. Considerable time is required to interpret the data on the tape into usable form, but with a fast-moving tape extremely small time values can be measured accurately. With coded identification of the elements, and the several means available for actuating the solenoids, the kymograph is a convenient laboratory instrument for certain types of research problems.

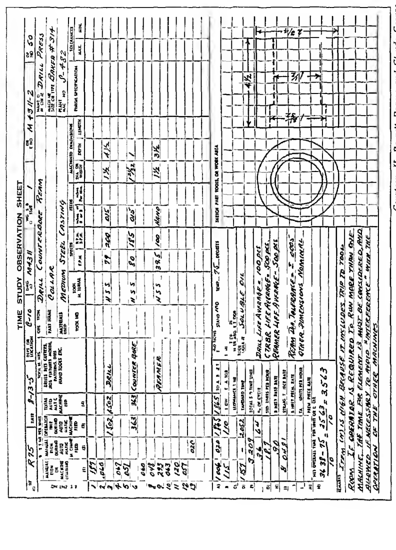
Although these various instruments are valuable research tools, they are rarely used in industry for every-day operations The stop-watch is the primary tool of the time-study engineer The camera is secondary to the stop-watch, and the other instruments are by comparison relatively unimportant when viewed from the standpoint of actual use



Courtesy Ralph M Barnes Motion and Time Study John Wiley & Sons

FIG 19 5 Electrically operated kymograph measures and records time Paper tape passes through the machine at a uniform speed of 2000 inches per minute, and solenoid-operated pencils mounted above the tape may be used to mark the beginning and end points of therbligs or of other subdivisions of an operation to be timed

Preparing the time-study observation sheet As indicated earlier the operation should be standardized before starting the time study Accurate records should be made of conditions before the standardization for later reference The observation sheet should contain as complete information as possible, not only as an aid in checking in the study while it is being taken but also to aid in checking it at some future date when the rates set on it as a basis may be questioned If conditions are carefully noted, they may be readily re-established at any future date, or at least it may be determined wherein new conditions differ Complete identification of the job will include such items as date of observation, name of observer, name of worker and perhaps his qualifications, material identification, equipment and tools, name and part number of the finished product, position of the operator—whether sitting or standing, height of work place, temperature, light, and possibly relative humidity, cutting speeds and feeds, sketch showing important dimensions (or occasionally photographs), and



Courtesy H Barrett Rogers and Claude George

FIG 19 6 Write-up side of time-study sheet (back of Fig 19 2), showing the method of calculating the standard allowed time for the operation, as well as data essential for future use of the time study for comparisons and the development of standard time data The sketch may be freehand and should be sufficiently complete to show the shapes and dimensions directly associated with the operation

any other possible data which may have any bearing on the manner of doing the work Many time studies are relatively worthless for later use because the observer failed to record complete details of the job conditions Figure 19 6 illustrates the pertinent data that should be recorded

The approach to the operator It seems that most people, workers, lawyers, college professors, and motion-study men, do not like to have their work measured The observer should keep this in mind and strive to establish a friendly relationship with the worker To secure accurate results the observer must stand in such a position that he can see exactly what the worker is doing and, as far as possible, exactly what the machine is doing also The observer ordinarily should be behind and to the side of, not in front of, the employee This will lessen the strain of being observed, which increases if the worker tends to look up to see what the observer is doing Usually, the correct position will be about 5 or 6 feet in the rear and to the right or left of the employee If the operator must stand, the observer also should stand, out of courtesy to the worker If the worker sits during the operation, the observer may sit if he can do so without being conspicuous or in the way of the operator or other workers In general, however, the observer should stand in order to see the operations better, to be more alert, and to make more accurate recordings on his study

How many observations should be taken? As in all sampling techniques a sufficiently large number of readings must be taken to obtain fairly representative times for the operation The number of observations of any operation that are required in order to secure sufficient information will vary with the type of work involved If a comparatively long time is necessary to perform each of the elements of the operation and it is clearly seen that the operator has achieved a rhythm that results in approximately a uniform rate of work, only a few observations, for instance 10 to 20, might be necessary This is especially true if the job involves work on automatic machines with a small percentage of handling time On operations of less than one-half-minute duration, perhaps as many as 100 cycles should be timed On longer operations, of, say, 15- to 30-minutes' duration, from 5 to 10 cycles may be sufficient In jobbing shops where orders are small, the observer may be unable to obtain readings on more than 1 or 2 cycles

Taking the time study Figures 19 2 and 19 6 show the steps required to take a time study Across the top are shown the descriptions of the various elements being timed In taking the study the observer will record elapsed time on the observation sheet, as indicated in the example It will be noted (Fig 19 2) that in the space below the elements will be found two sets of figures expressed in minutes and hundredths of a minute Those

in the space below R represent the continuous times or "readings," recorded as the study is made for the operation as a whole Those in the space below T represent the times for the elements, which are computed from the continuous times after the observations have been completed In the accompanying study the watch ran continuously from the beginning of the study until the end All happenings during the progress of the operation must be noted and explained on the observation sheet This practice is particularly desirable in a job study for developing standard conditions, so that all interruptions that have occurred, of whatever character, may be studied with a view to prevention of recurrence The disadvantage lies in the necessity of entering three or more figures instead of two for each observation taken after the pointer of the stop-watch has made one complete revolution This objection may be obviated, as is shown in Fig 19 2, by merely recording the total figures once or twice during each cycle A second method of reading the watch is to start over again at the end of each cycle A third method is to snap back the watch at the end of each element This method is not accurate for short elements It does, of course, have the advantage of recording only the actual times

Certain elements will be found in each cycle while others will not For example, in a drilling operation the drill may be too dull and the operator may have to remove it and go to the toolroom or stockroom for a new one This may take 5 or 6 minutes Containers that hold the parts may have to be changed The foreman may stop the worker by asking him a question These time-consuming activities should be noted on the study and allowances made for them

Determining the time for each element The time for each element is secured by subtracting the continuous time recorded below the prior element from the continuous time for the element in question For instance, on line 8, element 1 (Fig 19 2), the continuous reading is 2677 (the 26 is omitted in recording), and the reading for element 2 is 2682 By subtracting 2677 from 2682 the time for element 2 is found to be 0 05 of a minute

These individual times are usually accurate, because the stop-watch hand will make three forward moves each 0 01 minute Thus, if the hand were stopped, it would be possible to read down to 0 003 minute However, 0 01 minute is a close enough observation for almost any purpose, for the observer will ordinarily read up 0 01 minute as often as he will read down 0 01 minute, and any slight errors in observation of this nature will automatically adjust themselves

Micromotion studies The objective of a micromotion analysis as shown in Fig 19 8 is to discover exactly how the operation is performed so that it may be improved The making of a micromotion study in the form

of a simo chart requires considerable time and in many instances is not justified (see Fig 19 7) It is, however, an excellent training device and well worth making from time to time for training purposes if for no other

Name of Therblig	Therblig Symbol		Explanation suggested by	Color	Color Symbol	Dixon Pencil Number	Eagle Pencil Number
Search	Sh		Eye turned as if searching	Black		331	747
Find	F		Eye straight as if fixed on object	Gray		399	747½
Select	St	→	Reaching for object	Gray light		399	734½
Grasp	G	∩	Hand open for grasping object	Lake red		369	745
Transport loaded	T L		A hand with something in it	Green		375	738
Position	P	9	Object being placed by hand	Blue		376	741
Assemble	A	#	Several things put together	Violet, heavy		377	742
Use	U	U	Word "Use	Purple		396	742½
Disassemble	D A	++	One part of an assembly removed	Violet, light		377	742
Inspect	I	0	Magnifying lens	Burnt ochre		398	745½
Pre position	P P	8	A nine pin which is set up in a bowling alley	Sky blue		394	740½
Release load	R L		Dropping content out of hand	Carmine red		370	744
Transport empty	T E	◡	Empty hand	Olive green		391	739½
Rest for over coming fatigue	R		Man seated as if resting	Orange		372	737
Unavoidable delay	U D		Man bumping his nose, unintentionally	Yellow ochre		373	736
Avoidable delay	A D		Man lying down on job voluntarily	Lemon yellow		374	735
Plan	Pn		Man with his fingers at his brow thinking	Brown		378	746
Hold	H		Magnet holding iron bar	Gold ochre		388	736½

Courtesy Ralph M Barnes Motion and Time Study John Wiley & Sons

FIG 19 7 Standard symbols and colors for commonly used therbligs

reason Figure 19 8 is illustrative of the detail that may be shown for a link-forming operation Either the simo chart or the analysis sheet of the micromotion study may be made independently It is not necessary to make the simo chart in order to make the micromotion study A motion picture of the operations is helpful in making a micromotion study in that it facilitates getting all the detailed actions of both hands or other members

MICROMOTION STUDY

SIMO CHART

PART Link for typewriter DEPARTMENT 9 FILM NO C18

OPERATION Form link for typewriter OP NO G11

OPERATOR A S Sanders A2 DATE 2 15 37 MADE BY S A R SHEET NO 1 OF 1

DESCRIPTION LEFT HAND	TIME	TIME	DESCRIPTION RIGHT HAND
Returns clamping lever and releases it	2		
		4	Reaches for material
Moves hand to fixture	3		
		2	Selects and grasps one piece
Grasps formed link in fixture	6		
		6	Carries piece to fixture
Carries formed link to left and releases it	3		
Moves to clamping lever and grasps knob	3	6	Inserts piece in fixture and releases it
Moves lever to extreme left	3		
		2	Reaches for forming lever and grasps knob
Holds lever in this position	8	5	Forms 1st end of link
Returns lever to original position and releases it	3	3	Returns forming lever and releases it
Moves hand to fixture	3	4	Moves hand toward fixture and waits for left hand
Grasps piece turns it end for end in fixture and releases it	8	4	Moves hand to fixture
Moves to clamping lever and grasps knob	3	8	Assists left hand in turning piece end for end in fixture
Moves lever to extreme left	3		
		2	Reaches for forming lever and grasps knob
Holds lever in this position	8	5	Forms 2nd end of link
		3	Returns forming lever and releases it
Returns clamping lever and releases it			

FIG 19 8 Simo chart

of the body if they are involved A micromotion analysis is particularly valuable in calling attention to time when one hand is idle, this idle time may be avoided by a rearrangement of the sequence of operations The first micromotion analysis may be merely a tool to aid in perfecting the standard operation desired When all corrections have been made, a final micromotion study serves as a valuable record of the standardized operation

Synthetic time studies There are at least two kinds of synthetic time studies (1) those built up from time studies of similar operations in the plant using those elements that are common, and (2) those built up from basic body movements for which time values have been established Both Gilbreth and Taylor were advocates of the collection and standardization of data to be used by professional engineers in establishing time standards A substantial number of companies have built up over the years basic data from which they may estimate the time for new operations having the same basic elements as previous operations When careful data covering various elements have been accumulated, these data may be used in establishing synthetic time values for similar operations This is true especially when there are many different operations of a similar class of work, such as that on lathes, drill presses, or punch presses These elemental times, to be of use in building synthetic times, should be established with great care under standard conditions [1] When this has been done and a new job is to be undertaken, all that is necessary is to construct a detailed operation sheet for the task and select the appropriate elemental times for each element from time values already established for similar work The total of the elemental times, when adjusted for allowances for fatigue and other conditions, gives the operating time allowed for the operation The use of synthetic standard times enables the production department to plan its schedules even before the first piece has been produced Such a program is particularly valuable in estimating the cost of producing parts when quotations are asked with only the blueprint specifications available

Paralleling the development of standard time values from operational studies has been the work of others who have sought to determine elemental time values for the basic body movements A B Segur, a well-known management consultant of Chicago, has been using this method for more than 20 years Many of his clients and students are using his data More recently Harold Maynard, G J Stegemerten, and John L Schwab of the Methods Engineering Council of Pittsburgh have developed their Methods-

[1] See Ralph M Barnes, *Motion and Time Study* John Wiley & Sons, New York, 1949, pp 391–418, for an excellent discussion of the determination of time standards from elemental time data

Time Measurement, MTM as it is popularly known [2] They have measured the time required for the elemental body movements and built up data that enable them to study the required movements for an operation and to assign time values for each of these movements, thus establishing the proper standard time for the operation Their data are claimed to be more accurate than that obtained by an actual study with a stop-watch due to the inability of the observer to read the time values on the watch while he is watching the operation with the same high degree of accuracy as MTM has determined its values from reading films of the operation In this claim they are undoubtedly correct Some users of MTM also time the operation with a stop-watch as a check against the estimated time, and also for psychological reasons Maynard and his associates have published their data, which is in the best tradition of true scientists [3] In addition to the value of MTM in setting standards it is used in connection with methods improvements It tends to develop a motion consciousness in the analyst which leads almost inevitably to methods improvements wherever MTM studies are made

In general the steps in using established time values for elemental body movements are as follows

1 Separate the operation into its basic elements
2 Separate each operation element into its therbligs or elemental body movements
   2 1 If two or more body movements are executed simultaneously, the time required for the longest therblig is controlling
   2 2 In some cases simultaneous body movements do not have the same time elements as each movement does when executed alone This difference must be allowed for in computations (MTM has worked out these situations more completely than any published data known to the author)
3 Assign time values for each therblig in each operation element
4 Total the time values for each therblig in each operation element
5 Add allowances for fatigue and similar conditions to determine the required operating time
6 It is not necessary to apply a leveling factor when MTM values are used The MTM values are for the average man working under normal conditions at an average speed

Very rapid strides have been made in recent years in establishing time values for elemental body movements This field of research is a fertile one Using these established time values the observer studies the operation, breaking it down into its body movements, and assigns the proper value to each movement The total of these values plus the machining

[2] See Harold B Maynard, G J Stegemerten and John L Schwab, *Method-Time Measurement* McGraw Hill, New York, 1948

[3] See *Factory Management and Maintenance*, Feb , 1948, pp 98–104, and Aug , 1950, pp 84–91

time and allowances for fatigue and personal needs gives the allowed time for the operation The use of body-movement elemental time values does not remove the need for work simplification The operation should be simplified and standardized before establishing standard operational times Standard times established from body movements may often provide the basis for placing the operation on an assembly line even before the product or part is made It seems reasonable to predict that the future is bright for the establishing of synthetic time values for operations

20 ESTABLISHING TIME VALUES BY TIME STUDY

Selecting the operation time There are several methods of working up time-study data They may be termed the "average" method, the "minimum" method, the "modal" method, and the "good time" method They will each be described, but before they are taken up in detail, certain features which are common to them all will be pointed out The *first step* in any method is to throw out the "abnormal" times These are times recorded for individual elements that are clearly in error when compared to the other times recorded The error may be due to one of the following causes

1 Some delay which will seldom occur or some variation in the way that the element was performed which will seldom be repeated

2 The wandering of the worker's attention for instance talking to a fellow-workman A certain degree of lack of attention to a job not only is likely to occur but also is desirable, if undue strain is to be lifted from the workers Such time as is necessary for this, however should not be included in operation time but should be added in the form of an allowance, after operation time has been determined Other allowances must be added in like manner

3 Some mistakes on the part of the observer in reading the watch, which can generally be detected by the fact that the time of either the preceding or the succeeding element is likely to be abnormal, whereas the sum of the two abnormal times will be approximately the sum of the average times of the two elements

Striking out abnormal values, either higher or lower than the generally modal or recurring values, calls for fine judgment on the part of the observer Nevertheless, *it may be assumed that any time which varies more than 25 or 30 per cent from the average may be stricken out of the calculations* On short elements it is not always practical to adhere to the percentage basis There are a few kinds of work in which the abnormal values should be figured in, when working up the study These include construction work and repair work

When using the "average" method, which is the simplest, those individual element times that remain after the abnormal readings have been eliminated are averaged A more appropriate name for this method would be the *"selected average"* method (An occasional observer may use the straight

mathematical average or arithmetic *mean* without disregarding the abnormal times Such a plan is absurd when some of the readings are obviously abnormal, but it would probably cause no special difficulty if the variations are only on the borderline of being abnormal) If the average method is used, these average times will also be the average selected times and will be so indicated in the appropriate column of the observation sheet The selected operation time under this method is found by adding the average time of the separate elements This is the simplest method and the one commonly used The objection to this method is that it may make the individual element times and hence the final operation time too high, because it includes all observations other than those which were abnormal In adding allowances, these higher times are automatically taken care of, and this method has the effect of giving too much weight to the higher times

The *"minimum"* method takes the minimum for each element, namely, that time which, in all the observations, was the fastest for any one element, and then adds these to get the selected operation time (The minimum method excludes the abnormal times before selecting the minimum) In this method, therefore, the minimum time and the selected operating time are the same This has the effect of materially reducing the selected time below the value which would be found under the average method For instance, in the illustration given, the selected time for the complete operation cycle of 10 elements (Fig 19 2, p 19 3) would, under the selected average method, be 2 891 minutes, whereas under the minimum method it would be 2 777 minutes It is generally believed that this method is too severe and is not fair to the workman, even with the addition of allowances, since to choose the minimum time, which might have occurred only once out of 20 observations, usually means taking a time that is just over the 25 per cent borderline and is not quite thrown out

The modal method, in the opinion of some observers, has more to commend it than either the *minimum* or the *selected average method* The *modal method* selects the most frequently recurring element time in the observations as the time for that element Thus, in element 11 in the illustration, the time 0 12 recurs 5 times, whereas the time which recurs next most frequently is 0 13, 3 times Therefore, 0 12 would be taken as the selected time for that element The selected operation time is secured by adding the various element times thus secured If two elements recur with equal frequency, usually the average of these elements is taken The modal time is generally less than the average time and is, of course, always greater than the time secured by the minimum method The modal method eliminates the objections to the two previous methods and at the same time gives a selected time which can be achieved, as is evidenced by the fact

that it is composed of the elementary times which were themselves most frequently found

The "good time" method is merely the modal method applied with some degree of flexibility In the good time method a time which recurs with reasonable frequency is selected rather than the one which happens to occur most frequently The fact that the time recurs a number of times indicates that it can be made, and the justice of this method lies entirely in the interpretation of "reasonable" *A time to be reasonable certainly should appear in at least from 10 to 15 per cent of the observations The time selected may presumably be the modal time, but it is likely to be somewhat lower*

Leveling A substantial amount of the arguments about time values established by time study hinges around the process of *leveling* If the worker studied is an *average worker,* possessing *average skill,* working under *average conditions,* exerting *average effort,* and maintaining this effort with *average consistency,* the selected operation time will need no adjusting To the extent that the observed worker varies from the average skilled worker, an adjustment of the time will need to be made in the allowances, or by empirical judgment, or according to some scale that has been derived by experience Some time-study men argue strenuously against any formula type of leveling factor [1] It is undoubtedly true that the use of the table to be described (Table 20 1) requires judgment of the same type that is necessary in making adjustments empirically The table, however, has at least one value The observer is definitely required to evaluate at least the four factors of relative skill, effort, conditions under which work was performed, and consistency of work A conscious effort to evaluate these four factors will tend to give greater uniformity than an over-all estimate not broken down The selected operation time is leveled by multiplying it by a leveling factor obtained from Table 20 1 according to the following illustration Assume that the worker possessed excellent skill (B1), worked under fair conditions (E), exerted good effort (C1), and was average (D) in consistency The numerical equivalent for each of these factors added to unity algebraically would be the leveling factor, $0\ 11 + (-0\ 03) + 0\ 05 + 0\ 00 + 1 = 1\ 13$ Since the observed worker is above the average, it would be expected that his time would be shorter than the time required by the average man [2] By multiplying the selected operation time by 1 13, the time for the average worker would be deter-

[1] See Ralph Presgrave, *The Dynamics of Time Study,* University of Toronto Press, Toronto, 1944, Chap 6, for an interesting discussion of leveling

[2] If the observed worker had been below average the multiplier would be less than 1 Therefore the adjusted time would be less than the observed time

mined. This normal time would still have to be corrected for allowances for personal needs, machine setup time, and other such factors.

An interesting feature of methods time measurement is that its time values do not require leveling.

Table 20.1 Performance Rating Chart *

Skill			Effort		
+0.15	A1	Superskill	+0.13	A1	Killing
+0.13	A2		+0.12	A2	
+0.11	B1	Excellent	+0.10	B1	Excellent
+0.08	B2		+0.08	B2	
+0.06	C1	Good	+0.05	C1	Good
+0.03	C2		+0.02	C2	
0.00	D	Average	0.00	D	Average
−0.05	E1	Fair	−0.04	E1	Fair
−0.10	E2		−0.08	E2	
−0.16	F1	Poor	−0.12	F1	Poor
−0.22	F2		−0.17	F2	

Conditions			Consistency		
+0.06	A	Ideal	+0.04	A	Perfect
+0.04	B	Excellent	+0.03	B	Excellent
+0.02	C	Good	+0.01	C	Good
0.00	D	Average	0.00	D	Average
−0.03	E	Fair	−0.02	E	Fair
−0.07	F	Poor	−0.04	F	Poor

* Stewart M. Lowry, Harold B. Maynard, G. J. Stegemerten, *Time and Motion Study*, McGraw-Hill Book Company, New York, 1940, p. 233. Reproduced by permission of the publisher.

Allowances. The selected operation time taken from an average worker performing according to the average speed, etc., or the time selected for the operation time that has been leveled is not the standard time to be used for rate setting. Allowances must be added to cover such factors as the following:

1. Preparation time of the machine. It will be noted that the machine will have to be prepared to do a job only once, although the job may be repeated many times in succession. This is, therefore, in the form of an allowance rather than an element of the operation.
2. Necessary machine delay.
3. Fatigue of the operation.

4 Personal needs of the operator, oiling machine, etc

5 Material handling The operators frequently must move trays or pans of material to and from their machines or benches

6 Supervision received from the foreman or given to a learner or helper

7 Getting miscellaneous supplies and tools replacing broken tools or grinding tools if the operator grinds his own tools

8 Machine interference if the worker is operating more than one machine and the cycle becomes unbalanced One machine may become idle before the operator gets another machine started The chances for this type of idle time increase with the number of machines operated by one man

The preparation allowances may sometimes be determined with as much exactness as the selected time On the other hand, the provision for machine delay, fatigue, personal needs, and other such factors must involve as an element the judgment of the person who computes the allowance Therefore, *if care is not utilized in making the allowances, any amount of care utilized in timing the operation or selecting the unit times may be voided* The determination of the leveling factor is primarily a matter of judgment based upon experience and training In many cases this is also the basis of allowances, yet it need not be Careful studies should be made of individual machines, operations, and work centers to provide the data needed for making allowances Two methods may be used for securing these data (1) the *all-day delay time-study method* and (2) the *frequency ratio delay method* or *the work sampling study*

The all-day delay time-study method is the one most commonly used It consists of making studies of a group of workers or a work center for a period of a day or longer to record and analyze necessary delays This information is then broken down to correspond to the proper operations and applied as a percentage allowance For the frequency ratio delay method [8] the time-study man prepares a small pocket notebook with a separate sheet for each operator within a general work center [4] On each sheet is listed productive time and the various classifications of delays that may be expected Over a period of several days or weeks the observer will make many trips past the workers at various times of the day or week Each time he passes a worker, he makes a tally mark under the type of activity with which the worker momentarily is occupied After a reasonable number of tally marks (such as 50 to 100) have been collected for a work center, an accurate allowance factor can be determined Obviously the

[8] The author is indebted to Professor H Barrett Rogers for this description and for his assistance in preparing these chapters on motion and time study and also to Professor Claude George for his constructive criticisms

[4] See Robert Lee Morrow, *Time Study and Motion Economy* Ronald Press New York, 1946, Chap 16, p 176, for an interesting discussion of the ratio delay study for allowances

more tallies available, the more accurately the factor will represent the average conditions This method is not well known nor widely used, it is based on sound principles, however, and has proved highly satisfactory in actual applications It is economical of the observer's time because the tallies are made while the observer is on his way to perform other duties When there is a question as to the adequacy of an allowance the operation may be checked at regular intervals, such as 30 minutes, for several days as a specific assignment, thus applying the same principle as when checking as a matter of course when performing other duties The sampling technique has gained in popularity since the application of statistical quality control to inspection

The standard time *The selected operation time is the time in which the operation can be performed by a highly skilled worker under ideal conditions* The selected operation time can be "made," but is not usually made This manifestly would be an unfair basis for the setting of rates The time that is secured by leveling the selected operation time and adding the allowances is known as "standard time" The measure of the *fairness* of the standard time which has been set is the ability of the *average worker* to make it, and the ability of the superior worker under good conditions to excel it One purpose of motion and time study is to set a time which will enable the worker to accomplish the maximum amount of work with the minimum amount of fatigue With such a time standard maximum production can be maintained day after day One of the chief criticisms leveled at time study has been that it sets a rate which only the best workers can hope to achieve This criticism is not valid The leveling factor reduces the observed time to the normal time that an average worker can make By adding allowances the normal time becomes the standard time for the average worker, all the factors of the work situation being taken into consideration

Setup allowance time The setup time for a machine is the time required to get the machine ready to run the particular operation A setup may be completely or partially like that from the previous operation on the machine In many cases it is more logical to use the setup time as a separate operation, not including it in the operation time of the pieces manufactured In other situations the setup time is divided by the average number of pieces usually run, thus giving the setup time as a part of the selected operation time For instance, if it takes 100 minutes to make a setup for a machine that is to run 1000 pieces, the allowance per piece for setup will be 0 1 minute Illustrations of such jobs are to be found in great number in many industries, for instance, setting up a punch press and a turret lathe in metal working, a lining machine in stationery manufacture, and a loom in weaving

Delay allowances Delay allowances include allowances for lost time due to occasional variations in material and interruptions by supervisors, and machine delay allowances for delays due to difficulties with machines or equipment, which may be outside the control of the operator It is in the making of the delay allowances that the most care is needed, because, unless they are carefully set, they may be so large that all the previous care taken in making and working up the study may be wasted All-day time studies provide a rational basis for calculating appropriate delay allowances When conditions that modify the delays change, the delay allowance should be revised

Allowances for personal needs The time required for personal needs varies more with the individual than with the type of work, however, with the same individual more time will be required for personal needs when performing heavy work or when working under unfavorable conditions of humidity and heat than when doing light work or laboring under more favorable conditions It is not unusual for women to require more time for personal needs than men working under the same conditions The allowance for the personal needs of the workman is frequently calculated so as to take care also of the regular oiling and care of the machine This allowance is sometimes known as the "shop constant" because it is usually the same for all operations in the shop It is ordinarily based on a percentage between 2 and 5 per cent of the selected operation time

Fatigue allowances Fatigue may be defined as the reduced capacity to work arising from work itself Normal fatigue is weariness that is overcome by rest and need not be considered an industrial problem except for making due allowances in operating times, it may even be thought of as wholesome fatigue, which is similar to the pleasure derived from exertion in sports Cumulative fatigue, resulting from overstrain, can be caused by too much work, too sustained work, or too monotonous work Signs of the presence of cumulative fatigue may be found in a study of production or accident records within an organization If production tends to fall toward the end of the day or the end of the week, or if accidents seem to be unduly high at these times, it may be assumed that in the operations affected there is some cumulative fatigue which should be eliminated The study of fatigue provides a fruitful field for industrial research There is little evidence that modern industry, with persons working an 8-hour day, creates any cumulative fatigue that is harmful

The first factor in setting the fatigue allowances is the working conditions If the shop is clean, well lighted, and well ventilated, they may be disregarded, as far as fatigue arising from general working conditions is concerned If these conditions are not right and cannot be immediately made right, allowance must be made The next factor is the length of the cycle

of the operation In general, the shorter the cycle, the greater the necessary fatigue allowance The amount of physical exertion required must also be considered If a job requires considerable physical exertion, the influence of the fatigue factor is large On such jobs, however, the original study should extend over a large portion of a day, in order that the fatigue factor may directly influence the selected operation time The presence or absence of stated rest periods should also be considered

Rest periods Rest periods are important as factors in removing or reducing monotony as well as in reducing fatigue The influence of monotony is immeasurably greater than is ordinarily suspected On the other hand, a number of operations frequently termed monotonous are far from objectionable to many persons The attitude of the worker toward his job is largely controlling as far as monotony is concerned The following general principles may be stated with a fair measure of accuracy [5]

1 Monotony is less likely to arise when the machine is entirely automatic

2 Monotony tends to be reduced when the machine operation requires a high degree of concentration

3 Monotony is most likely to occur when the machine operation requires the worker to be ever watchful, yet not enough care is necessary to keep his mind fully occupied

Fatigue elimination consists of improving equipment, as discussed under standard equipment, eliminating useless and tiring motions, as developed by job study, varying the job so as to relieve monotony, and providing rest periods Stated rest periods of 5, 10, or 15 minutes during the morning and the afternoon are particularly successful with women workers, especially if machinery can be stopped during these times Professor Ralph M Barnes [6] has pointed out that rest periods are desirable in both light and heavy work for the following reasons

1 Rest periods tend to increase the amount of work done in a day

2 Rest periods are pleasing to the workers

3 Rest periods tend to encourage the worker to maintain a level of performance nearer his maximum capacity

4 Rest periods reduce physical fatigue

5 Rest periods reduce the amount of personal time taken out during the day by the worker

Total operation time The total allowed operation time for a given operation is the sum of the selected operation time for the operation plus

[5] See Elton Mayo *Human Problems of an Industrial Civilization,* Macmillan, New York, 1933 also H M Vernon, *Industrial Fatigue and Efficiency*, Routledge, London, for a detailed discussion of this subject

[6] See Ralph M Barnes, *Motion and Time Study,* John Wiley & Sons, New York, 1949, p 186

allowances plus the machine time plus allowances In the upper left of Fig 19 2, p 19 3, the time for each element is given Assume that the worker was rated as follows from Table 20 1 skill A1, effort C1, working conditions E, and consistency F This would give 1 13 as a leveling factor The other data would be as follows

	Operator	Machine	Total
Selected operation time	1 006	1 865	
Allowance factor	1 150	1 100	
Standard time (found by multiplying operation time by allowance factor)	1 157	2 052	3 209
Standard units per hour (60 — 3 232)			18 700

21 UTILIZING TIME-STUDY DATA

Establishing allowed times for incentive pay The basic function of the time-study engineer is to establish time standards for operations, not to place a price on the work Nevertheless the time established for a given operation materially influences the earnings of workers who are paid by any system based wholly or partly on productivity The fundamental consideration in rate setting is that a rate once set should never be cut by the management Any other policy results in workers being hesitant to turn out maximum production for fear that the rate will be cut The actual setting of the monthly rate may be in the hands of the rate-setting department, the superintendent or works manager, the personnel department, or a special wage and salary committee The setting of the wage level is primarily the responsibility of top management It may be delegated to the director of personnel with advice from the highest level of operating management A guarantee, usually placed on the instruction card which he receives, may be given the workman that the rate set will not be cut The exact wording of the guarantee is not particularly important so long as it conveys the idea that management is acting in good faith and will not change the standard times unless conditions are materially changed

Setting new rates by regrouping old elements We have already discussed synthetic time values (p 19 14) The use of previously established time values ranges all of the way from setting practically all new time standards from previously determined values to setting certain standards from data that have been used extensively We are not here discussing the use of elemental body-movement data but operational elements which include a series of sequential body movements To be in a position to compile time standards from previous studies implies not only excellent studies to begin with, but also a well-worked-out filing system for the data that have been secured Standard nomenclature of operations is also a great aid Comparatively few elementary operations are performed in most trades, but there are a great many combinations in which these few elementary operations may be performed Nevertheless, great care must be exercised in reusing time-study data to insure that the element in ques-

tion is in reality the same element studied previously, and that the conditions surrounding the new job are such that the information already secured may be freely utilized without injustice to either the workmen or the management. Many skilled time-study engineers contend that a standard time established from carefully proven standard elemental time values is more reliable than actual observation. The individual study may have errors that tend to be neutralized by many studies that have proven successful.[1] In many instances a skilled estimator, supplied with accurate studies of similar jobs and cost data, can sit down in the office of his customer and give him a price on a new job that exists only in blueprint form. This practice is not uncommon among parts manufacturers that sell to larger manufacturers.

The instruction card. Figures 21.1 and 21.2 illustrate two instruction cards, one for a machine operation and the other for a hand operation. The rate of pay is sometimes included on the instruction card. This device insures the utilization of the standard methods which have been established during the job study and gives each worker the best knowledge on methods of performance. It does not preclude innovations on the part of the worker, since he may recommend improvements, but it insures that any new methods which are used will be better than old ones and that they will be equally available to all workers on a particular task. The instruction card carefully details the method of doing the work on the job as well as the time allowed for the various elements.

When the instruction card is made out with the full details required for the job, it provides a record that can be used later when the same job is run. This information should include setup, tools, and methods of handling materials and tools. On new work which is not likely to be repeated, the instruction card forms a means of securing a profitable method from the first. On work which is repetitive, after the first few times that the operation is performed, the instruction card is less for the guidance of the worker as to method, since he is probably fully familiar with this, than it is for supervisors who may be checking up on the job from time to time.

Securing worker cooperation in checking time studies. Cooperation is a by-product of satisfying relationships. Cooperation in checking time studies will usually reflect the total cooperative attitude among the workers. Frequently a complaint is made by some operator that he is unable to reach the standard of performance called for on the instruction card. This may be due to one of the following causes or a combination of several

[1] See H. Barrett Rogers, "Practical Analysis of Time Variables for Standard Time Data," *Proceedings of the National Time- and Motion-Study Clinic*, Industrial Management Society, Chicago, 1941, p. 21; see also Ralph Barnes, *Motion and Time Study*, John Wiley & Sons, New York, 1949, pp. 391–418.

INSTRUCTION SHEET

Customer Amer Tool Co

Part Name Spur gear Case D

Part No 1073 A–F

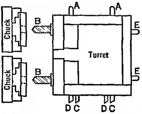
Operation Name Drill rough one side and ⅞ of outside diameter

Operation No 5 TR

Dept 11 Machine class, 58 Machine name, Jones & Lamson

Made by S R K Approved by S M Date 7–9–35 Mat l SAE2315

Tool layout



Set-up Time
New set-up 60 00
Change of size 30 00

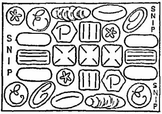
No	Procedure	Tools—jigs, etc	Speed Setting	Speed Ft / min	Feed Setting	Feed In / rev	Base time
1	Pick up and chuck 2 pieces						0 12
2	Start machine and true up (if necessary)						0 10
3	Change speed						0 03
4	Adv turret and throw in feed						0 06
5	ROUGH OUTSIDE DIAMETER (¾)	A ¾×1¼ in tools		70	71	0 014	2 32
6	Back turret and index						0 07
7	Advance turret, set headstock throw in feed and change speed						0 12
8	DRILL	B 1⁵⁄₁₆ in drills		60	71	0 014	0 08
9	Back turret and index						0 07
10	Advance turret and lock						0 08
11	Advance headstock change speed and throw in feed						0 08
12	ROUGH FACE 1 SIDE	C ¾×1¼ in tools		70	71	0 014	1 65
13	ROUGH FACE HUB	D ¾×1¼ in tools		30	71	0 014	
14	Unlock, back and index turret						0 07
15	Advance turret and set head stock						0 09
16	CHAMFER INSIDE FLANGE	E ¾×1¼ in Form tools		70	Hand		0 10
17	Advance head stock						0 06
18	CHAMFER HUB	E ¾×1¼ in Form tools		30	Hand		0 10
19	Back turret and index						0 07
20	Set head stock						0 12
21	Stop machine						0 03
22	Loosen and remove 2 pieces						0 10
	Total handling time for two pieces						1 47
	Total machine time for two pieces						4 55
	Total base time for two pieces						6 02
	Total base time for one piece						3 01
	Allowances 10 per cent						0 30
	Standard time in minutes per piece						3 31

Courtesy Ralph M Barnes Motion and Time Study John Wiley & Sons

Fig 21 1 Instruction sheet for turret lathe operation

½ LB BLUE RIBBON BOX (FLANGE) LIST No 4623-12

Cups	*Unit No*	*Name*	*Cups*	*Unit No*	*Name*
Round	203	Raspberry Cup	Round	376	Caramelized Brazil
"	204	Apricot Cup	"	392	Croquante Whirl
"	221	Strawberry Creme	"	393	Vanilla Caramel
"	275	Coffee Creme	"	394	Marzipan Sandwich
"	371	Orange Marzipan	"	396	Tosca Pate



Heavy lines = Foil Covered Units

Make weight with Accommodation Units, one less than weight of last Chocolate
If Light Add 1 Croquante Whirl, 1 Apricot Cup
If Heavy Take Out 1 Apricot Cup

	No		*Patt No*	*Paper No.*
Linings (Center) (Emb E Foil)	1	13, ⅜ × 6, ⅞	Shaped	8795
" (Ends)	2	4, ⅞ × 2, 15/16	3226	8796
Top-Pad	1	6, 13/16 × 4, 13/16		4990
" Stock No 04990—To be cleared first				
Cups (Round)	25			3569
Wrap	1	14, 13/16 × 11, ⅛	2716	142
Wrap fastened on bottom with Gloy, ends folded and fastened on bottom with Gloy				
Printed Identification Key	1	8, ¾ × 6, ⅞		5070

Snip—Brown
Filled on Printed Identification
Tear-off Price Seal (Stk No 2878) on wrap, top-left

Foil (Stock No 8666) Blue and Silver E Design—to be used when Stk No 08666 is cleared

FOILS

Stock No. 08666—Blue Printing on Silver

Width of Reel 3″ for Tosca Pate, Marzipan Sandwich and Strawberry Creme

Symbol No F 136
Outer No R 976—Packed ¼ dozen
Outer tied String—Single

First packing to be sent to Inspection Office

New Lines Office,
January 14, 1937.

Issued to Inspection Office from New Lines Office

Courtesy Ralph M Barnes "Motion and Time Study," John Wiley & Sons

FIG 21 2 Instruction sheet for packing chocolates

of them *lack of skill* on the part of the operator, *trouble with his machine or equipment, delays* which may have passed unobserved on the part of the time-study observer because they did not happen to occur while the study was being taken, an *incorrect time study,* or an *attempt by the operator to secure a more liberal time* by complaining If an operator seems to be unable to make his standard time with any degree of regularity, and this situation is clearly not his fault, it is essential that a new study be made so that it may be finally determined whether or not the task time that has been set is fair When the instruction card with full data concerning time values for the respective operations is placed in the hands of the worker, it is a valuable aid in securing his approval or criticism Giving the worker this information serves as an additional stimulus for the time-study department to be careful with its work On the other hand, sharing the time-study results indicates to the worker that the time-study man is "square"

Production studies The *production study* is similar to the all-day time study for allowances but the "production study" includes everything whereas the "all-day study" is concerned only with allowances The production study usually consists of the observation of the operator during an entire day's time, or such part of the day as he is working on the operation concerning which he has made complaint During the observation of the worker in this production study a *careful record is made of all times consumed, including a record of the element times in the same way that they were recorded when the time study was originally taken* The particular value of this type of study is twofold first, an opportunity is given to observe the effect of fatigue upon the worker, inasmuch as the study covers an entire day, which is an unusual length of time for an ordinary time study A production study is, therefore, quite as much a fatigue study as it is a job study, in reality it consists of a combination of the two It may conceivably happen that a time study which was accurate for jobs when they lasted only for a couple of hours will prove to be incorrect for the same jobs when they are carried on for an entire day The charting of the times consumed during certain hours of the morning and the afternoon may give the necessary information concerning fatigue upon which to base recommendations of change in time allowed for the operation, or possibly on which to recommend relief from fatigue by means of rest periods

Data obtained from the production study may direct the attention of the observer to the causes of the workman's inability to make his standard time For instance, if it should be found that the elements which are entirely handling time are being performed well within the selected element time, whereas the elements which are entirely machine time are running uniformly larger than the selected time, it is obvious that there is something wrong with the equipment or the method by which it is being used The

production study will clearly reveal whether a particular operator is unable to reach the time that has been set because of the time allowed or the conditions of the job, including himself It may reveal the fact that he is leaving his machine more frequently than is necessary, that he lacks skill, that the handling time and the time for the adjustment of the machine are unduly large, or that the equipment is in poor condition

There are mechanical devices that may be attached to machines that will record all delays and the reason for same by properly coding the charts These are particularly helpful when there is any question about the machining time

Automatic machinery The timing devices that make a permanent record are particularly valuable in studying the machining times of automatic machinery It would not be necessary to time study automatic machines if they were kept running all of the time at the proper feeds and speeds In all automatic machinery, tools become dull or require changing, the material supply may run low, or there may be a number of other causes for stoppages A time study of such machinery involves taking a production study for a period of a day or more to determine which of these stoppages are avoidable and which unavoidable If the machine-hour cost is high in comparison to the operator's hourly earnings, it is more important to concentrate on keeping the machine busy even though the operator may have idle time This statement of course does not hold without any qualifications For instance, if the operator's rate is $1 50 per hour and he is kept busy only 28 minutes during the hour to keep a $3 00-an-hour machine operating 99 per cent of the time, it will pay to let the machine operate 90 per cent of the time, provided that the operator will be kept busy an additional 30 per cent of his time and assuming that production requirements will stand this reduction Each case has to be carefully worked out in terms of the particular situation [2]

When the proper information is at hand, it is possible to set a rate of stoppages which will apply to a machine at all times when engaged on the class of work studied This will enable the shop to set standard times on the automatic machines which will be entirely within reach, in the same way that they may be set on any other machines in the shop The setting of the standard time merely involves taking the capacity of the machine and adding the allowances which have been found by the production study to be necessary

Gaining acceptance of motion and time study At times it is more difficult to gain acceptance of motion and time study from foremen than

[2] See Robert Lee Morrow, *Time Study and Motion Economy*, Ronald Press, New York, 1946, Chap 22, for an interesting discussion of this subject, also L P Alford and J R Bangs, *Production Handbook*, Ronald Press New York, 1944, p 529

workers One of the best methods of introducing time study in a plant that has never used it is by the "conference method" The program literally has to be sold both to the foremen and to the workers A class in time and motion study in which both the foremen and the representatives of the workers seriously study the objectives and techniques of time and motion study prepares them both for its use It is necessary for absolute honesty to prevail Time and motion study objectives should be clearly set forth

1 To find the one best method of performing a task with due regard to the fatigue of the workers The best method should be the easiest method

2 To provide accurate information as an aid in planning and estimating costs of new jobs on which the company is quoting

3 To serve as a basis for setting an equitable wage

Management should recognize that the worker expects to share in the benefits of increased production When standard times are once set, they should be rigidly adhered to unless conditions change fundamentally A broken promise is long remembered Full cooperation from workers cannot be expected unless a reputation for square dealing prevails

There is no one attitude of unions toward motion and time study Union attitudes range all of the way from bitter opposition to acceptance with the union's having its own skilled industrial engineers Union attitudes are discussed in greater detail in Chapter 45

PART 6 —— WAGE PAYMENTS BASIC RELATIONS OF EMPLOYERS AND EMPLOYEES

22 JOB EVALUATION

The need for evaluating jobs Whenever one type of work over a period of years commands a higher wage than another the higher priced jobs have been given a preferred status This preference is usually granted in terms of the demands the higher priced jobs make on the workers These job requirements include such things as physical requirements, mental requirements, skill, working conditions, and responsibility Unless there is some kind of planned comparison of jobs there is likely to be gross inequities in the pay for work in the company

Job evaluation is the *process of comparing jobs with other jobs in terms of the demands the jobs make on the worker* These comparisons may be in terms of (1) ranking or grading, or (2) point values For the job evaluation process to be really complete, jobs must be priced Price is not solely determined by the requirements of a given job The supply and demand factors play an important role Job evaluation does not set the price of a job, it merely shows the relationship between jobs which would determine price when other factors do not force a given job out of the normal relationship in terms of job requirements Evaluating jobs is a technical assignment while pricing jobs is a commercial or economic process The persons who evaluate jobs may set the rates to be paid on these jobs provided the general rate structure has previously been established It would be an unusual situation in which the job evaluation department would negotiate or establish the price level of the rate structure

The primary objective of job evaluation is to establish the relative requirements of jobs for the purpose of properly rewarding workers for the work performed There are several by-products of job evaluation, namely

1 It tends to eliminate wage inequities within the company

2 It provides a relatively objective basis for resolving wage controversies involving comparative rates

3 The job descriptions on which job evaluation is based provide the information needed for community wage surveys and comparisons

4 Job evaluation enables a company with plants in other areas to maintain a high degree of standardization even though the wage levels may be different

5 The job descriptions may provide information needed in establishing lines of promotion

PITTSBURGH PLATE GLASS COMPANY . . . *Job Analysis*

DEPARTMENT	Maintenance	DATE	10/20/48
JOB TITLE	MACHINE REPAIRMAN LATHE	SHEET	1 OF 2
JOB NUMBER 7	NUMBER EMPLOYED 1 M	FLSA STATUS	Non-exempt

JOB SUMMARY: Maintains plant machinery in a state of good repair by performing tasks such as repairing or replacing parts from stock or fabricating new parts maintains a supply of spare parts for Roll Mills and performs miscellaneous skilled and semi-skilled maintenance tasks as directed fulfills these duties by exercising a detailed knowledge of operations and procedures involved and utilizing a skilled proficiency in the use of standard machine shop equipment and tools

WORK PERFORMED

1 Repairs machinery and related equipment in accordance with instructions received from the FOREMAN MAINTENANCE observing operations to determine the cause of faulty performance dismantling machine as necessary to remove defective parts repairing, fabricating or replacing from stock such parts as shafts bushings bearings and gears and reassembling and adjusting machine to meet operational requirements fulfills this function by exercising analytical and mechanical ability and by skillfully utilizing standard machine shop equipment such as an Engine Lathe Drill Presses and Power Saws and a variety of hand tools (1-40%)

2 Performs maintenance tasks on the Roll Mills by repairing and replacing parts such as various regulator feed guides and adjustments and similar mechanisms to insure efficient and continuous operation exercising a detailed knowledge of the operation and using tools and equipment as necessary to affect repairs maintains a stock supply of Roll Mill spare parts in the Maintenance Department informing the CHIEF ENGINEER of needs when stock is low performs miscellaneous maintenance duties as assigned or in conjunction with duties outlined above (2 - 60%)

SKILL STATEMENT This is a highly skilled job which demands extensive experience in the machinist trades and requires the ability to perform mechanical operations requiring a high level of skill in machine shop work of all kinds and the ability to utilize equipment at hand to perform tasks normally requiring special tools or machines by improvising substitute methods and tools

Note For descriptions and details of the additional considerations of EQUIPMENT MATERIALS, SURROUNDINGS and HAZARDS refer to the Job Analysis for SPECIAL MECHANIC

Additional considerations (when significant) EQUIPMENT; MATERIAL; SURROUNDINGS; HAZARDS; COMMENTS

BASIC QUALIFICATIONS: Must be skilled in the set-up and operation of machine tools must have mechanical aptitude and analytical ability must be physically capable of lifting heavy machine parts

DEGREE OF SUPERVISION RECEIVED General FROM CHIEF ENGINEER FOREMAN MAINTENANCE
EXTENT OF SUPERVISION GIVEN see COMMENTS TO:

[illegible]

PREPARED BY O. C. Magel APPROVED BY E. W. Fiske
CHECKED BY C M Peterson W Wothers

Form 2613

FIG 22 1 Job description

The job description In order to evaluate jobs in terms of their requirements it is necessary to describe the jobs in detail This is achieved by first analyzing the jobs in terms of the requirements and then writing the descriptions in the light of the analysis of each job The description of jobs for purposes of job evaluation is immeasurably more detailed than the descriptions of jobs for employment purposes The job evaluation description gives particular attention to those requirements that are used in

PITTSBURGH PLATE GLASS COMPANY . . . *Job Analysis*

DEPARTMENT: Maintenance DATE: 10/20/48

JOB TITLE: MACHINE REPAIRMAN LATHE SHEET 2 OF 2

COMMENTS

The occupant of this job closely directs MECHANIC'S HELPER assigned to assist him in the completion of specific tasks

Form 2613 (Subject to revision for changes of method, equipment, material, product, etc.)

FIG 22 1 (*continued*)

the evaluating process A standard form is usually used on which the needed information is recorded to be used in constructing the job description The job evaluation itself is frequently somewhat more condensed than the job description from which it is made By using a standardized form of describing jobs the comparisons for evaluating purposes are facilitated Figure 22 1 is a job description of a machine repairman

Kinds of job evaluations Job evaluation plans may be divided into three main groups (1) the ranking or grading method, (2) point systems, and (3) the Factor Comparison Plan or the weighted-in-money method The simplest method is the ranking system in which jobs are ranked in terms of their over-all job requirements In arriving at these rankings jobs may be compared in terms of the same characteristics used in the other systems but not for the purpose of arriving at relative values of each of these characteristics This system should have careful job descriptions but it is possible to rank jobs without these descriptions It would be impossible to rank jobs with any degree of reliability without considerable familiarity with their requirements The advantages of the ranking system are (1) its simplicity, (2) its requiring less time than the other systems, and (3) its failure to claim the scientific accuracy that the other systems lay claim to Its disadvantages are (1) it does not tell how much one job differs from another, merely that it is higher or lower, (2) unless the same detail is followed as in the other systems the analysts cannot possibly be so familiar with the jobs as they should and hence the ranking is likely to be inaccurate, (3) in the absence of detailed analysis compromise plays an undue part, and wages paid for the job are likely to influence the ranking

The Factor Comparison Plan starts out with the money value paid to several key jobs and then breaks this money value down into the proportion that is considered appropriate for the various factors such as [1]

1 Mental requirements
2 Skill requirements
3 Physical requirements
4 Responsibility
5 Working conditions

After the key jobs have been rated on these characteristics the other jobs in the company are rated It is much easier to rate the other jobs than the first series of key jobs because the other jobs will fill in between the key jobs and may be compared characteristic by characteristic with the key jobs It will be seen that in the original evaluation the values ascribed to the jobs are related to the wages paid for these jobs After the first stages for evaluating the jobs the money value is dropped and that which was cents becomes points By comparing one job with another the points may be changed, thus, in fact, giving a specific job a higher or lower rating than its monetary value

[1] See Eugene J Benge, Samuel L H Burk, and Edward N Hay, *Manual of Job Evaluation*, Harper, New York, 1941, p 42

There are several point systems but they have a common characteristic in that point values are assigned to each job requirement Some point systems strive to keep the total points for the highest job within 100, thus to be able to compare jobs directly by an analogy to percentage One system adds 400 points to the actual job rating given by a point system related to 100 points but not tied directly to it There is a serious objection to making 100 points the highest value for a new job which may be created that has higher job requirements than 100 Should this arise, the system would be broken or all of the other jobs would have to be rerated Of course, the new job could be rated 110 or any such number This would change the system but it would be entirely satisfactory to do so

In reality it does not make any serious difference whether the top job is rated 99 or 999 The important thing is to rate them in terms of the base that is selected The point value given to the first characteristic that is rated in any job becomes the benchmark from which all other jobs are rated, provided, of course, that they are all kept within the relative framework of their true value to each other In a company where some job requirements are 3 times as great as the lowest one, there is some psychological advantage in rating the jobs on a higher scale than 100 The lowest rated workers do not react favorably to their jobs' being rated 30, but the same workers may not object to a rating of 60 or 70

Some advocates for the point system claim for it an accuracy not justified by the facts It is true that this system lends itself to a high degree of accuracy but this accuracy depends on the consistency of the rating of the jobs The Factor Comparison System has all the accuracy of the point systems but in the beginning it is tied to the monetary value of the jobs After jobs are rated by any of the systems they may then be grouped into classes with a maximum and minimum rate for each class [2] Of course workers that are on a job may argue that their job should belong in the higher classification This is especially true when the actual requirements of the lower job are about the highest in its classification One of the strongest temptations of management during the wage freeze of World War II was to upgrade jobs from one classification to another in order to be able to pay these men a higher rate and thus to hold them in a tight labor market Such a practice tends to destroy the job evaluation system

When jobs are carefully evaluated by any good system and placed in classifications, it is seldom difficult to place a new job in its proper classification This may be done usually without breaking down the new job into its detailed value for each characteristic It is a safer practice to go through all of the steps of evaluating each new job, yet both the workers

[2] The classification may also be done without going through the other systems

and management seldom have any serious difficulty in placing the new job in its proper classification by an over-all comparison rather than a detailed analysis

Advantages of trade association actions As was indicated above the point systems may have almost any number of bases Within a given company this causes no serious problem but it does not aid in comparing jobs with other jobs in the community The National Metal Trades Association has developed an excellent point system that is used extensively by its members By using a standardized system it is possible to compare jobs among different plants This is especially helpful in assigning rates to the different jobs One of the points of argument in wage determination is the claim of workers that the rates are lower than the going rates of other companies in the community Such a claim by either management or the workers is practically meaningless unless jobs can be compared This can only be done when the jobs have been carefully described If in addition to being carefully described they have also been evaluated by the same standardized system the comparison is more meaningful

Characteristics considered in evaluating jobs Most of the point systems include the same five characteristics used in the factor comparison system, namely

1 Mental requirements
2 Physical requirements
3 Skill
4 Responsibility
5 Working conditions

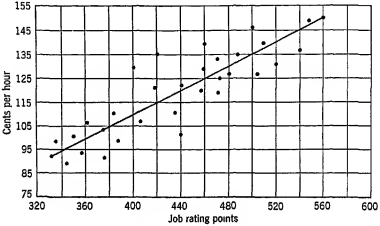
Some companies use as many as 11 different characteristics It is highly important that each characteristic be carefully defined and point values be assigned for the characteristics for well-known jobs so that norms that are generally recognized be accepted The National Metal Trades Association lists three factors under *Skill*, namely, (1) education, (2) experience, and (3) initiative and ingenuity Each of these 3 items is divided into 5 different degrees Some systems define skill in terms of the number of years required to learn the job or trade One company analyzed its characteristics used in its job evaluation plan and found that it could eliminate *responsibility* since responsibility in fact was included in skill In other words in giving due weight to skill, responsibility could be ignored They did not eliminate responsibility because the supervisors and workers both wanted to keep it in The important thing is not how many characteristics are included in a job evaluation system, but whether or not the ones used are pertinent and do in fact differentiate between job requirements To include too many factors merely increases points of disagreement

Job evaluation in office, sales, and supervisory positions Exactly the same principles are involved in evaluating clerical, sales, and supervisory jobs that are used in evaluating manual or factory jobs The primary difference is that the characteristics required are not the same Regardless of the job or position that is evaluated, the prime requirement is to identify those characteristics that are essential to success on the job The outstanding requirement of a radio announcer is that he have a pleasing voice and be able to read the script that is prepared for him Some people with an eighth grade education can meet this requirement, and others with a doctorate in English could not Most office positions are evaluated in terms of the following requirements (1) education in years of schooling, (2) accuracy, (3) memory, (4) supervision required, (5) special skills such as typing, shorthand, I B M machine operator, etc , and (6) relations with others, especially the public

When considering supervisory positions another set of requirements are evaluated These usually include (1) technical knowledge, (2) experience, (3) exercise of judgment, (4) planning, (5) conditions of work, (6) number of employees, (7) responsibility for equipment and product, and any other factors that the particular company may deem important The higher up the ladder of supervision the more difficult it becomes to evaluate supervisory or executive positions One large company in evaluating its executives considers the executive's responsibility for (1) planning, (2) policy formulation, (3) methods, (4) administration, (5) personnel relations, (6) executive contacts, (7) original thinking, (8) analysis, and (9) influence upon profits Naturally, the nature of the company would influence the relative value of these characteristics If the costs of materials going into the product were high and there were substantial opportunities for the purchasing agent to make real savings, the purchasing agent's position would rate higher than in another company where materials' costs were relatively standardized An industrial engineer's position in a manufacturing establishment would usually rank higher in relation to other major positions than the industrial engineer's position in a department store Likewise the industrial engineer's job in a mail order house is relatively more important than in a department store On the other hand, a sales manager's position in a department store and a manufacturing establishment would rank relatively the same in relation to other top positions In other words, the sales manager's position is a key position in both places

The use of job values The primary purpose of job evaluation is to establish the relative *job worth* of different jobs With the relative job worth of all jobs established, it is a simple matter to apply a wage level Of course this could be done by pricing any one job and then relating all

other jobs to it This would give a theoretically ideal wage relationship provided the job chosen truly represented the desired wage level and the job evaluation scale was correct Neither of these assumptions is likely to be absolutely correct It is usually better to select a few key jobs on the scale and to establish prevailing wages for some or at least the desired wage as related to the prevailing wage With these prevailing or selected



Courtesy Scott Clothier and Spriegel, Personnel Management,' Fifth Edition, p 183

FIG 22 2 Scatter Diagram of Hourly Rates and Job-Rating Points Indicating the Relationship between Two Variables Rate per Hour and Job-Rating Points This technique indicates the correlation between the two variables The independent variable (job-rating points) is plotted on the X axis and the dependent variable (cents per hour) is plotted on the Y axis The regression line (line of average relationship) is drawn by inspection This line may be computed, if a straight line relationship is assumed from the formula, by $Y = a + bX$, and the normal equations, *Sigma* $Y =$ $Na + b$ *Sigma* X and *Sigma* $XY = a$ *Sigma* $X + b$ *Sigma* X- For a more detailed discussion of this technique see John R Stockton, "An Introduction to Business Statistics," Boston D C Heath and Company, 1947 Chap XVI "Correlation," pp 380–394 and Chap XVII, 'Measurement of Correlation," pp 395–414

wages for the key jobs the others may be filled in The wage curve for manual work may be a straight line and not do too much violence to established custom Should a straight line be used as representative of the wage relationship it may be fitted to the selected key jobs by inspection or by actually performing the mathematical computations required In either case after establishing the desired-wage curve it is a simple matter to find the desired wage for any job for which point values have been established (Fig 22 2)

Usually there will be a different wage curve for office jobs than that used for factory workers The curve for office jobs may also be a straight

line In the case of executives the curve is most likely not to follow a straight line if the top executives are included in the job evaluation program

In the case of any job evaluation program there are likely to be certain jobs or positions that do not conform to the established norm If these jobs are lower than they should be it is a simple matter to get them in line On the other hand if they are higher than they should be it is not so easy to reduce them, especially if they are supported by a very strong union, such as the teamsters' union that represents truck drivers If union cooperation can be secured, one solution to the situation where certain jobs are being overpaid is to continue all present workers at the higher rate and to hire all new workers at the correct rate, and also to promote all the older workers as soon as possible to jobs whose rates are equal to or higher than the rates they are now getting In the case of other jobs, such as truck drivers, about the only thing that can be done is to pay the higher rate, recognizing fully that they are out of line Of course, they could be rerated and given a higher evaluation than the facts call for but this is a bad practice

A similar situation of rates being out of line may arise in almost any kind of work in case of extreme shortage of the particular skill For instance, engineers were exceedingly scarce during World War II and the Korean War Due to this scarcity they were able to command a wage higher than others with similar job values It is highly probable that this condition will adjust itself with a change in the demand for engineers

Keeping job values up-to-date Like any other managerial procedure job evaluation may get out of balance unless it is constantly watched Job contents and requirements change Unless these jobs are rechecked to include the changes, they will not represent the true job requirements For instance, if a milling machine operator has to set up his own machine a great deal more skill is required than when he merely runs a machine that is set up by a skilled setup man If the same job values are retained by a milling machine operation when a setup man has been added, it is evident that the job is over-rated It is highly necessary for the supervisor to notify the job analyst when job content changes so that the ratings can be kept up-to-date at all times

23 THE BASIS OF INDUSTRIAL WAGES

The influence of wages on economic and social life Wages paid cannot be considered in the absolute but must be considered in relation to those paid by other companies in the same field of business or in the same community, and in relation to the economic needs of the workers as well as the goods and services available to be purchased The higher the wages that are paid, *up to a given point of maximum return,* the more effectively the organization will operate The smaller the amount of wages that is allowed to flow through the economic organization, the less balanced and effective it becomes Ordinarily, the scale of living of the worker is, at any given time, directly dependent upon the amount and the purchasing power of the wage which he is receiving Usually he has no accumulated surplus upon which to draw and no sources of income other than his daily wage Therefore, the wage that is paid places or lifts restrictions on the home life and recreation of the worker and affects his personal life in a way unknown to any other factor of management

From the standpoint of the worker, or his standard of living, the real wage is the vital factor The *real wage is measured by the goods and services that can be purchased with the monetary wage* The *monetary wage* is represented by the actual monetary units that the individual receives A worker who receives $84 per week and has to pay $80 per month house rent with other living costs proportionate is in a relatively worse position than another worker who receives only $48 per week and pays $40 a month for house rent with other living costs correspondingly low An increase in wages without a corresponding increase in output usually means that prices rise, that money is worth less (inflation), that persons such as aged pensioners, widows, or others who have a fixed monetary income have a lower standard of living, and that the workers receiving the increase are relatively little, if any, better off than before wages were raised Of course, raising wages for one group may in fact improve the standard of living of this group by giving it a larger share of the total goods to be distributed It is unfortunate that the great mass of our population does not understand the relationship of the wage level to the standard of living

The satisfactory wage Many persons talk about a "fair" or "just" wage When you pin them down to an explanation of what they have in mind, they have difficulty in pinpointing *what they really mean* Unless one is committed to some form of socialistic or communistic philosophy he has to admit that fair wages must be related to productivity [1] The productivity of an individual has never been satisfactorily measured under our present industrial system Life is so complex, and the relations of one person to production are so inexact, that it becomes practically impossible to determine the extent to which he has added to the goods of the world The factory worker of today performs but a small part of the production of an article The machine on which he works and the building in which he works not only have been designed and furnished by the employer and the management, but also have in the first instance been created by other workers The economic theory of marginal productivity is helpful in theoretical discussions, but it is difficult to apply on a large scale to changing industrial conditions Our idea of justice in the abstract must be tempered by practical considerations in its application to social conditions [2] Even the most communistic minded would scarcely expect a private employer to pay a janitor with 14 relatively young children a wage high enough to provide them with the standard of living that most people would like to see them have There may be some logic in a large governmental unit's underwriting large families, but this is an entirely different matter from a private employer's paying different wages to men doing the same kind of work, merely because one has a larger family than the other

There can be no general definition of the meaning of a satisfactory wage, inasmuch as its limits differ so greatly under varying conditions However, it can be stated that a satisfactory wage must bear the scrutiny of employees, and, at times, of the community The general attitude of the community is not likely to affect an individual plant unless the plant is the main or basic industry of the community, or unless, as in a localized industry, a large portion of the community other than those who actually work in the plant secure their livelihood as a result of the wages paid within the factory In the final analysis a wage that is as high as the prevailing wage in the community for a given classification of work or one that will enable the em-

[1] This concept is not universally held by students of ethics or economics The communistic philosophy has frequently been expressed "To each man according to his needs, and from each man according to his capacity" More recently in Russia it seems for practical purposes to be, "To each man according to his performance, and from each man according to his capacity" (See Z Clark Dickinson, in *Compensating Industrial Effort*, Ronald Press, New York, 1937, pp 65, 84, 134n)

[2] See Frank C Sharp and Philip G Fox, *Business Ethics*, D Appleton-Century, New York, 1937, pp 181–194, for an interesting discussion of the ethics of a fair wage

ployees to maintain the standard of living to which they are accustomed, whichever is higher, may reasonably be called a satisfactory wage.

A satisfactory wage should command the support of all groups connected with the industry and of the community at large. If it does, presumably the wage is approaching an equitable wage. Because of all the factors which have been described, however, it is better to think of the proper basic wage in industrial plants as being a satisfactory wage, rather than a just, fair, or equitable wage.

While a satisfactory wage will be in keeping with the prevailing rate for similar work in the community, this alone is not a sole measure, particularly when the productivity would justify a higher wage and the standard of living is lower than is desirable.

The basis of a satisfactory wage. *Supply and demand, cost of living, and individual productivity* provide the foundation for wage determination. All three of these factors influence the base rate but no single one solely determines it. Supply of and demand for a given type of labor unquestionably have a large influence on the wage paid in most plants in the moderately long run. The workers, through organized labor and its attendant policies of the union shop, restriction of apprentices, and elimination of overtime work, have sought to limit the supply of workers. As either the employer or the employee gains the upper hand in connection with demand and supply for workers, wage rates are seen to fluctuate. Rates are not reduced immediately when the labor supply exceeds the demand and the unemployed worker would be glad to secure employment at a lower wage. The "going rate" in a community tends to be perpetuated for some time after a reduction in the demand for labor. As a matter of fact wage rates make up one of the most rigid costs in production. In the long run wage rates tend to be set largely on the basis for which the worker can be secured, that is, what he can get elsewhere in the same community. Large organizations having plants in different cities pay different wages in each plant for the same work, depending upon the wage levels in these communities. Although supply and demand for labor have a direct, moderately short-run effect upon wages, good management makes no attempt to follow *closely* the ups and downs in the labor supply with wage changes.

The General Motors Corporation's union contract as of April, 1953, recognizes this situation as follows:

"The establishment of wage scales for each operation is necessarily a matter for local negotiation and agreement between the Plant Managements and the Shop Committees, on the basis of the local circumstances affecting each operation, giving consideration to the relevant factors of productivity, continuity of employment, the general level of wages in the community, and the wages paid by competitors."

Characteristics of a satisfactory wage plan Wages should possess certain rather fundamental characteristics if the long-run interests of workers, management, and the consumer are to be served These characteristics are

1 The worker should be given a *guaranteed minimum wage* to protect him against conditions over which he has no control (This does not mean a guaranteed annual wage, although this is desirable where economically feasible, but a guaranteed minimum wage for the days when he works)

2 *Base wages* for each job classification or skill *should be related to each other* in terms of job requirements, due consideration being given to such factors as skill, length of time required in learning, versatility required, and working conditions Wage levels in different communities may vary, but the different skilled jobs tend to bear the same general relationships to the common labor rate in each community

3 Within a given classification or skill, *wages for different workers should be primarily in terms of output* Motion and time study techniques should be used in establishing standards that may reasonably be expected

4 The wage plan should be easily related to *cost controls* and the operating labor budget

5 The wage plan should *facilitate the comparison of relative efficiencies* of various departments or operating units

6 The wage plan should *make adequate provision for learners* (Experienced workers should not absorb the cost of teaching beginners)

7 The wage plan should be *simple and easily understood* by the workers

8 The wage plan should *not involve excessive clerical costs*

9 The wage plan *should be flexible* in order to meet changing conditions

Wages and the cost of living The relating of wages to the cost of living was not ushered in by the now famous contract of General Motors of 1948 The Philadelphia Rapid Transit Company for years successfully operated a wage plan that was directly related to the community cost of living Their index was known as the Market Basket Index The unsettled conditions arising from the outbreak of war in Europe and previous interpretations of the legality of collective bargaining under the then-existing Cooperative Plan (1938) led the company to discontinue the Market Basket Index as of December 31, 1939 The system used was quite simple The arithmetical average of the prices charged for commodities in the local stores was weighted by given quantities The resultant costs were compared with the costs of the same or similar commodities in the base year 1925, and an index number for each group was thus obtained The percentage change was, in turn, weighted by the group weight, and the sum of these changes determined the Market Basket Index

During World War II a few companies had a cost of living contract The wage freeze of the Korean conflict really did not freeze since the Wage

Board recognized the cost of living clauses in union contracts While cost of living adjustments are highly favored while they are on the upswing they are not so popular on the down side of the cycle Although it is desirable to increase wages to meet the rise in the cost of living, and in general either wages should rise with increased productivity of labor or the cost of the product should be lowered to the consumer, it is also true that there is strong argument for lowering wages when the cost of living drops This does not mean a frozen standard of living, but rather an intelligent recognition of the relationship among wages, costs, and the price of goods which is primarily controlling in the cost of living

The various cost of living indexes are usually tied to the Bureau of Labor Statistics Cost of Living Index The Bureau changed its base in 1952 but continued the old index into 1953 to avoid the confusion that arose because of the change

Productivity as a basis Productivity can be viewed as a partial aid in determining relative wage rates, and all of the work in job study and in the development of particular wage-payment systems which has been carried on in industry has had this end in view If an engineer is employed, it is to be presumed that he will be paid at a higher rate than a laborer in the shop This difference is due not entirely to supply and demand, but partly to the concept of individual productive capacity The higher rate paid the engineer is largely due to the prevailing concept that engineering in terms of job evaluation has higher total requirements than common labor Of course within any given job or occupation it is not so difficult to compare the productivity of workers While workers above the level of manual work are seldom paid in direct proportion to output, the higher producers usually get a higher wage Certain clerical jobs and many manual jobs are paid on a direct output basis The level of the rate per unit is influenced in part by job evaluation

Wages above the community level Most employers or at least a relatively large number of them say that they strive to pay a somewhat higher wage than that prevailing in the community From the very nature of the situation it is *impossible for the average employer to pay more than the average* A more accurate statement of the wage philosophy held by these managers would be that they desire to pay a wage as high as the prevailing community wage or in some cases higher than this rate "High wages and low unit costs" was the central theme of Taylor's *Differential Piece Rate Plan* The policy of most organizations with modern management involves the payment of higher wages than would be paid under the older types of management This higher wage may be returned through the lowering of overhead costs because of increased production and other benefits that are

secured through complete cooperation between the management and the workers If this is the goal, together with a recognition of the importance of wages as a factor in industrial management, the question of exactly how wage levels should be set decreases in importance

The sliding scale A wage system based on a sliding scale is usually one that is related to selling price of the finished or end product A formal sliding scale, adopted in advance, will not succeed unless the commodity being manufactured has a wide, competitive market, with open quotations on current selling prices Thus the sliding scale may easily be introduced into the manufacture of pig-iron because quotations on finished pig-iron are easily ascertainable [3] It may be introduced into cotton spinning, because its fluctuations may be readily based on the selling price of a particular grade of cotton yarn The sliding scale is not, however, applicable to a specialty business The method of determining the way in which the scale of pay will fluctuate with the scale of selling prices is a matter for bargaining, but ordinarily the increase or decrease of the wage should bear approximately the same relationship to the increase or decrease of the selling price that wages bear to cost of production in the particular industry or plant

This method of wage payment has found little use in the United States, although it is considerably more popular in Europe, particularly in England It generally works to best advantage in negotiations between bodies of employers and unions, since it involves the acceptance of the plan on the part of employees, this is difficult to obtain except where they are organized In certain regions of the British mining country the coal miners have had wide experience with sliding scales of wages based upon the selling price of coal In 1921 the sliding scale of wages was tied not only to the selling price of coal but also to the average profit margin in the district [4] Some careful students of the subject are of the opinion that such a program results in somewhat steadier employment [5]

[3] The Anaconda Copper Mining Company s contract formerly had a sliding scale provision The contract between The Eagle-Picher Mining and Smelting Company and the United Cement, Lime and Gypsum Workers, Local 280, dated April 24, 1951, has the following provision

Article VI Wages Sec 1 A sliding wage scale based upon the price of zinc concentrate is hereby agreed upon to become effective upon the date of the signing of this contract when the price of zinc concentrate is Sixty-Five Dollars ($65 00) per ton, or less For each One Dollar ($1 00) per ton increase or decrease in the price of zinc concentrate above the base of $65 00, wages will be correspondingly increased or decreased One Cent ($0 01) per hour

[4] See Z Clark Dickinson, *Compensating Industrial Effort*, Ronald Press, New York, 1937, pp 345, 350

[5] James A Bowie, *Economic Journal*, Vol 37, Sept, 1927, pp 384–393

Some employers have what is variously called a *wage-bonus*, *wage-dividend*, and *profit-sharing* plan, which is related to one aspect of the sliding scale, namely, increases Woodward Governor, Sonnen Products Eastman Kodak, Lincoln Electric, and other companies have used such plans If the volume of business and profits justify, the employees are given some form of an increase in earnings or a share in profits, the amount being usually related to their base earnings

24 WAGE-PAYMENT PLANS NOT BASED ON CAREFULLY ESTABLISHED TIME STANDARDS

The approach Our approach in discussing the various wage-payment plans is from the viewpoint of management as a representative of the public, the consumer, the owner, and the workers. From this viewpoint the wage plan is designed to get the maximum production from the worker that is compatible with his health and full cooperation. In treating this subject, there is no necessary conflict between this viewpoint and the standpoint of the worker or the welfare of the community. Actually in the long run these interests are mutual. In considering wage-payment systems it is well to keep in mind the requirements of the cost-accounting department of the business as well as of the production and general-management forces. Systems which involve the collection of a multiplicity of data may conceivably succeed in increasing output and thus decreasing the unit labor cost, but may fail because of the excessive cost and difficulty of collecting data for payroll and cost purposes.

The day rate Payment by the day is payment primarily for time which includes the hourly, daily, and weekly systems. *All incentive systems,* including straight piece work, *are related in their initial* conception to time, since they presume a given quantity of work for the expected average earnings within a specified work period. A large proportion of the industrial workers of the United States are today being paid under some form of the day-rate system (Table 24.1). Unless the worker is so inefficient as to merit discharge or so expert as to be raised into a higher wage classification, it is unlikely that his individual rate will be changed. Thus the amount or quality of work which he does has little bearing on the wage which he receives, except over long periods of time. Under the straight day rate there is little to urge a worker toward greater production except loyalty to his task or some spurring action on the part of his employer or his direct superior.

Workers often favor the day rate, because under it they can determine in advance what their wages will be. That all workers of a given class generally receive the same pay constitutes no objection for some workers. In fact, they tend to approve this situation, because it encourages a unity of action, through union organization, of all members of the wage group, if it

seems possible to secure an increase in the rate For these reasons day rates, once raised, are frequently as difficult to lower as any other kind [1] In the main, labor unions have tended to favor the day-rate system Unions exist for the benefit of their membership as a whole, and therefore anything which will tend to increase the unity of purpose of their members is likely to enlist their support The day rate is a perpetual influence toward solidarity in the union Substandard workers look to it as a means of raising their wages far beyond anything they could expect under a system based on merit or output The average worker is likely to be satisfied with the prevailing wage The best workers are likely to be striving constantly to increase their incomes and in doing so will tend to increase, along with their own incomes, those of the other members of the labor group The best workers, who, under other systems of payment, are least likely to be interested in unions, under the day rate are likely to be the prime movers toward organization It is their only hope for increased wages Thus they frequently begin to combat the management, whereas under other circumstances they may be made management's greatest supporters

Some unions are strong advocates of incentive systems, particularly the piece rate During World War II, when wages were largely frozen, some unions turned to some form of incentive system based on output as their only method of securing an increase in income For more than 35 years the men's garment workers in Chicago have been operating on some form of incentive wage payment which pays for productivity per worker This is one of the most highly organized and disciplined groups in the union movement

Day rates should provide no cause to slight quality Plants or departments on which quality is a paramount consideration are likely to be on day rates Nevertheless, effective foremanship and newer methods of wage payment make possible high-quality production without the day rate

Regardless of the type of wage-payment system that may be in use, it is usually necessary to compensate certain workmen by the day rate This group of workmen includes not only supervisors, but also men whose work is so diversified, incapable of standardization, or temporary as to make it impossible or impracticable to work out a satisfactory incentive system The hour, rather than the day, may be used as the time unit In this case the worker's earnings are computed as follows

$$E = RN$$

in which R signifies the rate per hour and N the number of hours worked

[1] The student should keep in mind that day rate, as used here, refers to a system in which accurate standards have not been set It is possible to have a system of time payments based on job study with carefully set standards of performance The objection cited above does not hold under such measured performance

Use of incentive plans Table 24 1 shows the distribution of wage plans among 628 companies This table shows that many companies have more than one wage plan The trend has been definitely away from the complicated systems that involve a great deal of clerical work and are difficult

Table 24 1 Wage-Payment Plans for 628 Companies, 1953 *

	Yes		No		No Answer	
	No	Per Cent	No	Per Cent	No	Per Cent
1 Do you pay straight time (day rate) to direct labor?	521	83 0	59	9 4	48	7 6
2 Straight piece rate (without guaranteed day rate)?	39	6 2	457	72 8	132	21 0
3 Group or gang piece rate?	111	17 7	391	62 3	126	20 0
4 Piece rate (with guaranteed minimum)?	195	31 1	325	51 8	108	17 1
5 Task and bonus rate (similar to Gantt)?	38	6 1	439	69 9	151	24 0
6 Premium plan (Halsey, Barth, Rowan, etc)?	44	7 0	435	69 3	149	23 7
7 Increased efficiency plan (Emerson)?	21	3 3	451	71 8	156	24 9
8 Group bonus plan (Wennerlund)?	57	9 1	428	68 2	143	22 7
9 Differential piece rate (Taylor)?	14	2 2	454	72 3	160	25 5
10 Point premium plan (Bedaux, Haynes, etc)?	46	7 3	437	69 6	145	23 1
11 Contract method?	39	6 2	434	69 1	155	24 7
12 Sliding scale (selling price of product, etc)?	7	1 1	462	73 6	159	25 3
13 Measured day rate?	34	5 4	441	70 2	153	24 4
14 Do you pay a dismissal wage to employees permanently discharged through no fault of their own?	184	29 3	393	62 6	51	8 1
15 Any other system than above?	72	11 5	265	42 2	291	46 3
16 Do you regularly make adjustments in your wage scale on the basis of cost of living changes?	307	48 9	291	46 3	30	4 8

* Source *Personnel Study No* 8, W R Spriegel and Alfred Dale, Bureau of Business Research, University of Texas, 1954

for the worker to understand The various needle trades, rubber industry, machine shops, and various standardized types of industry use straight piece work, the standard hour, and some type of bonus plan most extensively In metalworking and the needle trades piece rates are still the most popular, followed by the standard hour and some form of bonus plan The statement that there is a trend toward simpler forms of wage payment should not be interpreted to mean that the Bedaux and similar systems

are no longer in use The Bedaux is one of the popular systems, partly because of its inherent merit when considered along with the efficient management techniques that accompany the wage plan and partly because of the aggressive promotion of an able management-consulting firm Incentive plans are used in practically all types of industries, mass-production and semi-mass-production enterprises and job shops Although the various incentive plans are utilized more frequently on direct labor jobs, they are also used for maintenance men, truckers, packers, stockmen, and crane men

Piece rates not based on time study Piece rates have without time study usually been set with strict regard to previous day-rate earnings and previous performance They have usually been determined by dividing the day rate by the average units of production in order to secure the proper rate per unit Frequently the rate has been made somewhat less than this amount, on the assumption that production will increase under piece rates and thus the unit labor cost will be lowered First-class workers on repetitive jobs have usually been anxious to be placed upon piece work, inasmuch as it gives them an opportunity to profit from their accumulated skill and knowledge of the job The prospect of direct monetary gain is likely to result in the worker's studying the method of performing his job He becomes receptive to improvements in methods He is not receptive to such improvements, however, when he fears that they will result in cutting the rate

Workers have difficulty in recognizing that they should be paid for *the work that they do,* and that, when management makes improvements, they may often produce as much as 1 3 times the former number of pieces with no increase in actual work on their part One objection to any form of piece rate is the fact that workers tend to think of such rates as being *fixed* in relation to the pieces themselves and that they should never be changed (except upwards) Management, of course, is at times to blame for this attitude, either because of undue emphasis on the piece rate, rather than the amount of work involved in producing the piece, or because of making changes of no significance merely to alter rates Low producers and those on diversified jobs on which the setting of piece rates based on past performance is difficult are not likely to favor piece rates This is a perfectly natural attitude, since the substandard worker will have to exert himself more to earn his normal day rate, also diversified work does not lend itself so readily as repetitive work to piece rates

Rate cutting Workers usually can increase their production by 50 per cent over their old day-rate production when they seriously apply themselves under any incentive plan Some employers are tempted to cut the rates when they see the workers going much beyond the 50 per cent in

earnings This desire to cut rates may arise from the pressure of competition, the desire for increased profits, or both The action of rate cutting is equivalent to informing the employees that there is a maximum of earnings beyond which workers of any general class will not be permitted to go Such action, once taken in an organization, or fear of such action based on practices in other organizations, causes workers to hold their production under piece rates at the easily attainable figure which it is thought the employer has set as his maximum If rates have once been cut, this figure will at times be so uniform throughout a shop as to amount almost to an exact limit Changes in method have at times been bitterly fought by workers for fear that under the new method and new rate they would be unable to make as high piece-rate earnings as under the old method Really radical modifications in production method, which so change the job as to make the past rate absurd, have been frequently regarded by workers merely as *an excuse for cutting rates* This confusion between logical piece-rate readjustments and rate cutting results in numerous borderline cases which are difficult to settle amicably because there are no real data, convincing to both sides, which may be used as a basis

Learners' rates under piece rates Formerly it was common practice not to give a guaranteed day rate in a straight piece-rate plan Under such a plan it is necessary that a special "learner's rate" be established, which is usually on the day-rate basis The length of time that the learner remains on day work varies with the type of operation and with the factory, as well as with the training system that the plant has installed The learner's rate usually starts at a low point and gradually increases up to the point at which the worker is put on piece rate Another method of providing for the learner is to pay a flat day rate, such as 75 cents per hour for a short period, and then reduce the day rate during successive periods, allowing the learner the lowered day rate plus his earnings on pieces completed at the regular piece rate Such a program provides a strong incentive for the beginner to make a special effort to increase his speed of learning In the absence of some such sliding day-rate scale, it is not at all infrequent for a beginner to work the full learning period on the day rate and then refuse to go on piece work, giving as his reason that he cannot make out on piece work

Advantages and disadvantages of piece rates Any incentive system presents difficulties when the wage level rises or falls Piece rates have the disadvantage of being somewhat inflexible If rates have been raised during periods of high wages, they are usually decreased during periods of depression and falling wages Such lowering of wages is, of course, a cutting of the piece rate This situation results in very perplexing problems which have been solved by some plants, not by increasing piece rates, but

rather by giving a "cost of living" bonus, or, if the rates are increased, by placing the wages from the increased piece rate in a separate pay envelope In times of depression, when orders are scarce, the piece rate has an advantage over day rates or any of the other systems which guarantee minimum earnings to the worker Under such conditions many plants are operating from hand to mouth on orders, and this situation is as well known to the workers as to the management The piece rate does not invite the employee to stretch available work so as to insure himself a job under such conditions

Piece rates are far better than day rates from the cost-accounting and cost-estimating standpoints but are not ideal, as contrasted with some other systems The direct labor cost per unit of product or per job becomes a fixed amount, which may be accurately determined in advance But, since the time of doing the work varies considerably, the amount of overhead expense which will have to be distributed to an operation or an order is an unknown quantity before actual performance This same criticism holds with equal force for most of the other incentive plans Earnings are easily computed under a piece-rate system Expressed in terms of a formula earnings = the number of pieces times the rate per piece, or $E = NR$ If the rate per piece is 15 cents and the worker completes 48 pieces in a given day, his earnings will be $48 \times \$0\ 15 = \$7\ 20$

The pull of incentive wage systems *Incentive wage systems awaken interest and inject the spirit of competition into industry An incentive wage,* in order to be effective, *must generously reward the worker for the additional application, following of instructions, increase in output, and quality of workmanship which are required to earn the additional wage* In Taylor's experiments he found that increased effort on the part of certain classes of workers could be stimulated only by paying incentives above the base rate as follows [2]

	Percentage
Machine-shop workers doing general work	30
Laborers performing work calling for severe bodily exertion	50–60
Machinists doing delicate and difficult work	70–80
Machinists performing work requiring close application, strength, skill, and brains	100

It should be emphasized that cupidity on the part of management is equivalent to signing the death warrant of any incentive scheme If the reward is large enough, the worker will be enabled to take new pride in his job The pride of accomplishment in relation to his fellow-worker develops

[2] See Frederick W Taylor, *Shop Management*, Harper, New York, 1911, p 26

This is a perfectly logical and justifiable pride, and there is no evidence to show that it results in the setting of a killing pace

Any wage scheme which gives the worker a percentage of the savings incident to increased production and yet prohibits innovations in manufacturing method or merely inclines the worker to peg his production at a somewhat higher point than formerly, because of fear of ultimate wage cutting, will not be beneficial for long Rival plants, whose rates are set on the basis of newer manufacturing methods, or whose workers have not pegged production even at the relatively high level, will always be able to underbid because of lower manufacturing costs This is the basic reason behind changes of rates when the process or operation is changed It is essential that any wage-payment system which is devised so arrange the remuneration that the permanent cooperation of both the workers and the management will be assured

Symbols used in wage formulas The formula for computing earnings for piece rate was given as follows $E = NR$, in which E represents the earnings per day or period, R signifies rate per piece, and N stands for the number of pieces produced R is used in other wage plans to indicate the rate per day or whatever other unit is used as a basis for payment Other symbols that will be used are as follows

S = standard or allowed time for completing a particular task To illustrate, if the standard for a given piece of work is 10 minutes and a worker completes 6 pieces his S, standard or allowed time, would be 1 hour even though the actual time worked may have been 50 minutes or even 70 minutes

T = actual time spent in performing a given task

p = premium percentage

The Halsey premium wage plan F A Halsey, while superintendent of the Rand Drill Company of Sherbrooke, Canada, devised his gain-sharing plan It sets a standard time, usually by ascertaining the average previous time of doing the job, and offers the workman an agreed percentage of the wages of any portion of this time that he may save, in *addition to his hourly or daily rate for the time consumed on the job* As originally conceived and generally used, the standard time under this plan is the standard of past performance, however, there is no reason why a standard time determined from time study cannot be used under the Halsey plan *Since the Halsey plan gives the worker only a portion of his saving if time study is used as the basis, it is essential to set the standard time somewhat higher than the time which can be made, in order to provide sufficient incentive for the worker* The task time set by job study thereby becomes a base for the management to work from rather than a task to be reached However, under the Halsey plan the standard time is usually the average of previously recorded times It is usual to guarantee that, when the time is once set for

a job, it will not be reduced, despite the fact that conditions may not have been standardized or the jobs studied

The system is *liberal with the time allowance rather than with the premium percentage* Day rates are *guaranteed* under this plan Men who finish their tasks in less than the allotted time are paid, in addition to the base day rate, a proportion ranging from one-quarter to one-half of the wages of the time saved The wage under the Halsey system is equal to the *time taken* times the *hourly rate,* plus the *time saved* times some *fraction of the hourly rate*

$$E = TR + (S - T)\frac{R}{2}$$

This formula is for an allowance of 50 per cent of the hourly rate The fraction of the hourly rate that is most generally used is about 33⅓ per cent, if conditions have not been standardized or the job studied If the job has been studied, the fraction of the hourly rate that is used will ordinarily be around 50 per cent The percentage of the time saved—from 30 to 50 per cent—probably represents a rather large part of the total wage, and to make the percentage larger would be likely to create a distinct temptation to the employer to reduce the standard time when shown that it was considerably longer than actually necessary Another method of expressing the formula for computing earnings is as follows

$$E = TR + p(S - T)R$$

To illustrate the working of this plan, consider a workman who is on an hourly rate of 90 cents per hour and has an 8-hour task given him, which he completes in 6 hours, working with a bonus of 50 per cent of the time saved He will receive

$$6 \times \$0\ 90 + \frac{8 - 6}{2} \times \$0\ 90 = \$5\ 40 + \$0\ 90 = \$6\ 30$$

It will be noted that he receives $6 30 for 6 hours' work, which is at the rate of $1 05 per hour, or at the rate of $8 40 per day, provided his time on the next job, which he may start immediately, is as good as the time on the first one

The Halsey plan is easy to introduce The plan is excellent in any shop *as a transition plan* to be used while studies of the jobs in the shops are being made and to arouse the interest of the workmen in incentive wage systems This plan, in a slightly modified form, received its greatest amount of advertising from its use in the shops of the Yale and Towne Manufacturing Company, where it served as a transition plan The Halsey plan pro-

motes the permanence of the rate because of the method of dividing the profit on time saved between the employer and employee. If an extremely large amount of time is allowed for one job, and as a result the workman makes a very great saving of time, only a portion of the saving is given to the workman, this prevents the employer from immediately desiring to reduce the rate. Standard times under the Halsey plan are sure to be uneven in that some will be very high and some will be comparatively low, resulting in an unjust payment plan with "fat" jobs and 'lean" jobs. Furthermore, the workmen can beat the game by spurting on certain jobs to earn a premium and "soldiering" on other jobs to rest under *the guarantee of day wages*. This entire difficulty can be overcome by using time study instead of past experience as a basis for rate setting.

The Rowan plan James Rowan of David Rowan and Sons of Glasgow, Scotland, gave his name to a plan that has been more popular in Great Britain than in this country. Wages, instead of being raised by an arbitrary percentage applicable to all similar jobs, are increased by a percentage equal to the percentage of reduction which the worker has made on the standard time of the particular job. This premium is a percentage of time worked, rather than of time saved. The day rate is guaranteed. The premium under the Rowan plan can never equal the day rate, for the value of the fraction $(S - T)/S$ constantly approaches unity as the actual time T approaches zero. Under the Halsey plan daily earnings can be greater than twice the day rate. Ordinarily the premium is larger under the Rowan plan than under the Halsey plan. If the Halsey premium is $33\frac{1}{3}$ per cent, the Rowan premium will always be larger up to $66\frac{2}{3}$ per cent of the time saved. If the Halsey premium is 50 per cent, the Rowan premium will be larger up to 50 per cent of the time saved. The Rowan plan is far less widely used than the Halsey plan, chiefly because the method of figuring wages is so difficult that the worker finds it hard to understand and even harder to know what he has earned at any given time. It involves the use of a large clerical force for payroll purposes. Cost predetermination under either the Halsey or the Rowan plan is very difficult. The Rowan plan, like the Halsey plan, is very satisfactory during a period of transition from day work to a strong, measured incentive plan.

If a worker finishes 36 pieces in an 8-hour day while working on a job for which the standard is 32 pieces per 8-hour day, his earnings at a base rate of 90 cents per hour will be as follows:

$$8 \times \$0.90 + \frac{9 - 8}{9} \times 8 \times \$0.90 = \$7.20 + \frac{1}{9} \times \$7.20 = \$8.00$$

25 WAGE PLANS BASED ON CAREFULLY ESTABLISHED TIME STANDARDS

Standards provide an incentive A standard of performance is itself an incentive when made generally known to employees When the employees know that the standard is low, there is a tendency to keep performance relatively low so that management will not find out what may reasonably be expected On the other hand when the standard has been carefully established and the employees are shown that the standard can be made without undue effort or injury to their health, there seems to be a strong urge to make standard Of course, a group may have a strong sentiment against making standard and deliberately restrict production where there is distrust of management

Wage systems based on accurately predetermined tasks stimulate the worker to perform his task in the standard time which serves as the basis for production controls Budgeting, standard costs, and other managerial controls are facilitated if the approximate time required to perform tasks is predetermined When the task has been accurately set on the basis of fair time for the job, the worker should receive all the advantage which is gained by his reduction of working time below task time Therefore, these systems push the management quite as much as the management pushes the worker In considering the foregoing statement, it should be remembered that job study may be used as a basis for setting a given task and yet the task may deliberately be set below what is known to be easily attainable by the average man This is done when it is desired to build a wage program in such a manner that the bonus becomes a relatively large part of the daily earnings of the average man Such programs frequently share with management the time saved

Piece rates based on carefully established time standards These rates readily can be guaranteed by the management if provision is made for a change in the rate when the operation is changed Piece rates thus set become an incentive wage because the worker realizes that there is no cause for him to peg his production In order that such rates actually may be an incentive wage, it is essential that, after the job studies, his

pay be appreciably higher than his previous wage or the prevailing community day rate Piece-rate earnings are easy to compute as follows

$$E = NR$$

It is common practice to have a guaranteed day rate that is paid the employee when he falls down on his production due to factors beyond his control Sometimes the guaranteed minimum corresponds to what would normally be a day rate Payment of the predetermined average earnings over a recent period is usually made when the worker is transferred to a new job for the convenience of management The payment of a guaranteed minimum rate to the worker places the desired share of responsibility on the supervisors Day rates are frequently used for piece-rate workers starting new jobs, such as making new models in a mass-production industry

Day rates based on production There are two broad classifications of day rates based on output (1) a series of rates related to productivity, and (2) one high day rate when the worker reaches standard production and a lower day rate when he falls short of standard Day rates based on performance provide for a number of classes of operators for any given job These classes have their limits, fixed by the production of the workers As the productivity of an operator increases or decreases, he moves from one of these classes to another and consequently has his rate changed If records covering the performance of a number of workmen have been accumulated, it will soon be found that the workers will divide themselves into fairly well-defined classes which can have different rates of pay assigned to them It is unnecessary that the individual be working always on the same job or type of job to utilize this system If a record of the individual productive efficiency of each worker is kept for whatever task he may be working on and then all the workers are divided into distinct wage groups, based on their general efficiency rather than their efficiency on any one particular task, this system may be used on all jobs Under a scheme of this sort, advances or decreases in the worker's rate may be made at intervals of 1 month, 3 months, or any other period that is deemed best

Day rate based on production provides for day rates for jobs rather than for workers Each job has a day rate assigned to it, which is far larger than the worker can earn by the ordinary day or old-fashioned piece rates in force in the factory up to this time At the same time that this high day rate is established, a standard is set for the job If the worker makes the standard or excels it, he receives the high day rate If he fails to make the standard, he drops back to the old day rate or piece rate of the job or is paid by a new piece rate figured out in such a way that the worker suffers

a loss in his pay envelope because of his failure to make the standard For the most effective operation of this type of wage-payment system, it is necessary that the worker's performance be figured over relatively long periods of time and that he be not deprived of the high day rate merely for failure to make the standard over a comparatively short time This system has the advantage of the easy computation of the payroll that is characteristic of the day-rate scheme, and at the same time it enforces high production It is very useful in plants where the workers object to the piece rate In style industries, on which new rates must be set constantly, the use of day rates based on production is simpler than most forms of incentive payment Since a worker has had assigned to him a day rate based on past performance, on short jobs that have not been time studied and which it may be unprofitable to study he may be given the day rate which he has had previously He may also be kept on this same day rate while production standards are being worked out for new jobs on which standards ultimately may be set

Measured day work Measured day work is an outgrowth of an attempt to recognize other factors than production in a wage program and still retain many of the advantages of the incentive plans Measured day work establishes standards of performance by careful time study and sets a basic hourly wage for each job classification The employee receives, in addition to the base rate for each job classification, added inducements based upon his dependability, versatility, quality of output, and productivity Length of service and other factors may be included if desired The base rate for the job classification remains constant as long as the method and the conditions of the work or the general wage level remain unchanged The added inducement which is part of the individual's wage may change from time to time, depending upon the worker's actual performance over the past period evaluated The length of this period may be 1 month at the beginning of such a wage program but is usually increased to 3 months after the system is thoroughly established Careful records must be kept of the worker's attendance, quality of work, productivity, and similar factors to enable the foreman periodically to evaluate his relative worth to the company In establishing the base rates, each job is carefully evaluated in terms of such factors as

1 Mentality required to perform the work
2 Skill required of the worker
3 Responsibility for material and equipment
4 Physical application and energy required
5 Mental concentration required
6 Working conditions

Measured day work places an additional burden upon supervisors to keep production per worker up to task, however, this problem is not so great when workers are placed by a conveyor It does, however, become significant where the assembly line is not used *Clerical work for payroll purposes is much less than under many of the incentive plans, but the work necessary to collect the data needed for periodically evaluating the individual's addition to his base rate raises the clerical detail to approximately the same level as that of most incentive plans* Workers will not complain when their ratings are being raised, but friction can easily develop when an individual's rating is lowered Measured day rates eliminate complaints from the workers about shortages in their pay, which are frequent under incentive programs A criticism of measured day work is that the basis is shifted from "an engineer's job standardization to the personnel man's job analysis " [1]

Taylor's differential piece rates [2] In keeping with Frederick W Taylor's other scientific systems, his wage plan requires carefully established time standards and standardization of work, work place, and materials The plan has two piece rates a high rate, which is paid to workers who make the set task or do better, and a low one, which is paid workers who fail to achieve the task The high rate is set at a point considerably above the loose community standard, and the low rate is set at a point below the community standard Thus the task time for a given job may be 2 hours, with the high rate \$3 00 and the low rate \$2 00 If the worker does the job in 2 hours, he receives \$3 00, which is equivalent to a rate of \$12 00 per 8-hour day If the worker takes 2¼ hours, he receives \$2 00, a rate of \$8 00 per 8-hour day This last figure is somewhat misleading, since it may be assumed that no worker allowed to work under this system would fall down on every job during the day The system is severe on the worker who fails to make the task The formula for computing daily earnings under Taylor's system is

$$\text{Below task} \quad E = NR_1$$

$$\text{At or above task} \quad E = NR$$

R_1 stands for the low piece rate, which is intended to be a penalty for not reaching a task R is the standard rate that the worker is supposed to earn The assumption is that the management has gone to great trouble and expense to insure that all management factors are properly working,

[1] See Charles W Lytle, *Wage Incentive Methods*, Ronald Press, New York, 1942, pp 142–143 This book is a classic in its field

[2] Charles W Lytle, *Wage Incentive Methods*, Ronald Press, New York, 1942, pp 142–143

and the only causes for failure to do the task within the allotted time are under the control of the worker If the worker is a first-class man, he will make his task If he is not a first-class man and cannot be trained to be a first-class man, he is not wanted, in fact, if he continuously fails to make his task, he will be discharged

The Taylor differential piece rate is used very little in its original form in industry today (Table 24 1) The culling action at the point of achieving the task was found to be so extremely severe that the measurement of the task and the control of conditions set for the workmen had to be guarded with extraordinary care in order to avoid complaints or feelings of injustice on the part of the workmen The fact that the Taylor differential piece rate does not guarantee a basic day wage is, therefore, the primary reason why it has fallen into disuse Mr Taylor recognized this point himself, for he said

> When, however, the work is of such variety that each day presents an entirely new task, the pressure of the differential rate is sometimes too severe The chances of failure to quite reach the task are greater in this class of work than in routine work, and in many such cases it is better, owing to the increased difficulties, that the workman should feel sure at least of his regular day's rate [3]

The Gantt task and bonus wage plan Under Gantt's wage plan, not only does the workman receive a reward which is large enough to make him want to make standard, but also he *is guaranteed his hourly rate if he fails to reach the goal* If he accomplishes the task, he is paid at his regular hourly rate for the time allowed for the task, plus a percentage of that time This is equivalent to a high piece rate Thus the workman has all the advantages of day work on a task he does not meet and all the advantages of high piece rates if he is proficient The basing of a high rate on a day wage, although it takes the form of a piece rate, makes it possible to assign different rates for varying lengths of service or all-round abilities The task and bonus system is built on the idea of the worker's earning the bonus every time This point is of some importance when considering the relative merits of this system and differential piece rates H L Gantt, while associated with Taylor at the Bethlehem Steel Company, devised his task-and-bonus system, which Taylor in his later life strongly advocated Both Taylor and Gantt paid a bonus to the foremen Gantt gave an additional bonus to the foreman when all his men attained their tasks This system is not suitable for use in a transition period

Gantt's bonus ranged all of the way from 20 to 50 per cent of the task rate He actually varied the bonus percentage all the way from 20 per cent to 100 per cent, depending entirely upon the nature of the work On

[3] Frederick W Taylor, *Shop Management*, Harper, New York, 1911, pp 78–79

the assumption that the bonus is 33⅓ per cent, which is fairly typical for ordinary machine-shop work, the formulas for computing the daily earnings under the Gantt plan are as follows

$$\text{Earnings up to but not including task} \quad E = TR$$

$$\text{Earnings at or above task} \quad E = SR + \frac{SR}{3} = \frac{4}{3}SR$$

To generalize this formula to include any percentage that may be used as a bonus, let p represent this percentage The formula will then read

$$E = SR + pSR$$

Let us assume that A, B, and C respectively produce 28, 32, and 36 pieces in a day of 8 hours, that the bonus is 33⅓ per cent, that the task calls for 32 pieces per 8-hour day, and that the rate is 90 cents per hour The respective earnings will be as follows

1 A will earn 8 × 90¢ = $7 20 since he gets the guaranteed day rate
2 B will earn 8 × 90¢ + ⅓(8 × 90¢) = $9 60 or 1⅓(8 × 90¢) = $9 60
3 C will earn 9 × 90¢ + ⅓ (9 × 90¢) = $10 80 or 1⅓(9 × 90¢) = $10 80

Gantt's system is in substance a day wage for substandard workers and a task rate for men who are standard or better This task rate is equivalent to a high piece rate expressed in terms of standard hours rather than in terms of individual pieces It is possible to compare the efficiencies of different departments by comparing the standard hours worked in each to the actual hours worked The Gantt system avoids the criticisms that are made of the sharing principle common to the Halsey and similar plans Also, it is easy for the worker to compute his wage The Gantt plan, when installed under the guidance of Mr Gantt, made wide use of charts to show the worker daily just where he stood in relation to attaining a task Such a chart showed not only the status of the individual worker but also the corresponding status of his fellow-workers, thus creating friendly rivalry [4]

Task systems as an aid in cost predetermination and production control When a strong incentive is provided the worker to make a well-established task, he will tend to make the task every day The making of task every day facilitates cost predetermination and production control Under the task and bonus system the day rate holds until task is reached Under the task and bonus system there is a sharp jump in earnings when the worker meets task This makes the task and bonus system exert a stronger pull than the gain-sharing systems or piece rates Thus it is pos-

[4] See Charles W Lytle, *Wage Incentive Methods*, Ronald Press, New York, 1942, pp 185–189, for a detailed discussion of the Gantt plan

sible to predetermine overhead costs and use these overhead costs in developing standard costs Furthermore, the steady pull exerted upon the worker to reach the standard makes it possible to schedule and dispatch operations in the shop with the assurance that machines will be available at stated times The task and bonus systems are applicable to almost any type of operation that can be placed on any of the incentive types of wage payment They have been used to pay for producing individual units, clerical work, and operating delivery trucks

Emerson plan Harrington Emerson, like Taylor and Gantt, gave his name to a wage-payment plan Emerson's plan *guarantees the base pay rate and pays a graduated bonus beginning at 67 per cent efficiency, culminating with a 20 per cent bonus at 100 per cent of standard or above standard* In addition to the 20 per cent bonus based on the day rate times the time actually worked, Emerson *paid for the full production in terms of standard time* for all production *above standard* Under this plan the efficiency of the worker is determined over a pay period or even longer There is thus less drive on the worker to make task time on each particular job There is a gradual pull on the worker A man who is 98 per cent efficient makes more nearly the wage of the 100 per cent man than under the Gantt task and bonus system Workers who are over 100 per cent efficient under the Emerson plan do not receive quite the wage of the workers under the task and bonus system, for they receive their basic wage for the allowed time, but their bonus (which is usually 20 per cent) is figured on the time actually worked rather than the allowed time The efficiencies are expressed in terms of a percentage Thus, if in one period a worker has actually worked 96 hours and has done only work for which the standard time is 84 hours, his efficiency is 87½ per cent If he has done work for which the standard time is 105 6 hours, his efficiency is 110 per cent A sample bonus table under the Emerson system is as follows

Emerson Bonus Percentages

Percentage of Efficiency	Percentage of Bonus	Percentage of Efficiency	Percentage of Bonus
67 00 to 71 09	0 25	89 40 to 90 49	10
71 10 to 73 09	0 5	90 50 to 91 49	11
73 10 to 75 69	1	91 50 to 92 49	12
75 70 to 78 29	2	92 50 to 934 9	13
78 30 to 80 39	3	93 50 to 94 49	14
80 40 to 82 29	4	94 50 to 95 49	15
82 30 to 83 89	5	95 50 to 96 49	16
83 90 to 85 39	6	96 50 to 97 49	17
85 40 to 86 79	7	97 50 to 98 49	18
86 80 to 88 09	8	98 50 to 99 49	19
88 10 to 89 39	9	99 50 to 100 00	20

The formula for computing earnings according to the Emerson plan is as follows

Earnings from $66\frac{2}{3}$ per cent of task up to task $E = TR + p(TR)$
(The value of p is to be found in the table above)
Earnings at and above task

$$E = TR + (S - T)R + 0.20TR, \text{ or } E = SR + 0.20TR$$

On the basis of Emerson's bonuses the wages earned by the man whose base rate is \$1.25 per hour, working a 40-hour week under the percentages of efficiency indicated, for a pay period of 2 weeks will be

Percentage of Efficiency	Base Rate	Bonus	Total Wage, 2 Weeks
$87\frac{1}{2}$	\$100.00	\$ 8.00	\$108.00
95	100.00	15.00	115.00
110	110.00	20.00	130.00

Since efficiencies are determined over a pay period, a man cannot work at maximum pressure on one job, thereby making a very high rate, and then take things easy on the next job, with assurance of a good day's wage. However, under the task and bonus system disciplinary action may eliminate any such program on the part of a worker. Under the Emerson plan, earnings of the workers are posted daily, thereby mitigating somewhat the criticism that the plan is difficult for the worker to understand. The system creates much clerical detail and from this standpoint is expensive. In spite of its difficulties some progressive industries are using the system at present (Table 24.1). The Emerson and similar systems of graded bonuses exert less pressure on the worker to make task time than the task and bonus systems.

The Bedaux system The Bedaux plan formerly expressed standard times in terms of points, thus making possible the comparison of the efficiencies of departments.[5] Task times are now expressed in terms of standard work minutes or standard hours.[6] If a particular operation calls for 30 *standard work minutes* or *standard units,* the worker is allowed 30 minutes for its completion. The wage earned is equal to the money value of the total number of standard work units produced. Day work and lost time that are not the fault of the worker are paid for at the rate of 60

[5] To illustrate, if the total point hours of production in a given department are 9000 and the actual number of hours worked is 8000, then the efficiency for the particular number of hours worked will be 9000/8000 = 1.125, or 112.5 per cent

[6] Standard work minutes were formerly called B's, 60 B's making an hour or a B hour

standard work units per hour The operator receives the base rate for each operation plus a fraction of the base rate expressed as "premium standard work units," or payment for the additional standard units which he has done If standard base rates are not reached, the operator nevertheless receives such a rate for his performance This amounts to a guaranteed day rate The Bedaux plan makes careful use of job standardization and time study The Bedaux engineers do not claim to have a standardized program for all situations but lay great emphasis upon adjusting their program to suit individual needs For many years in most cases where the point plan has been newly installed, the full time saved has gone to the worker [7] This means that a worker having a \$1 20 base rate would receive 2 cents per minute for every standard minute of work produced over and above the standard productivity of 100 per cent (60 points per hour) When this is the case, $E = SR$

The formulas for computing the earnings of the worker under the Bedaux plan are as follows

$$\text{Earnings at or below task} = TR$$

$$\text{Earnings above task} = TR + p(S - T)R$$

where p represents the percentage agreed upon as the share of the time saved to go to the worker S is found by dividing the number of standard work units by 60

Beginning operators may be paid a rate below the standard base rate and need not be advanced to the standard rate until, by maintaining a production of 60 standard work units per hour for several successive days, they have indicated that they are capable of earning the base rate that has been set

The one hundred per cent time premium The 100 per cent time premium plan assigns a task time for each operation Each class of work may have a specific rate per hour, or the worker may be given a definite rate per hour regardless of the work he performs The worker's time and efficiency relative to the standard task must be accumulated for each job in order to compute his earnings for the day This is true regardless of whether the rate is assigned to the worker or the job The worker is usually guaranteed the base rate for each job To illustrate, let us assume that a worker works 4 hours on job A, for which the rate is \$1 00 per hour, and produces 5 standard hours of work, then finishes the 8-hour day on a job for which the rate is \$1 10 per hour, producing 4 standard hours His earnings will be $(5 \times \$1\ 00) + (4 \times \$1\ 10) = \$9\ 40$ If the rate

[7] Letter to the author from F A Mattka Director of Research and Development Bureau, Albert Raymond and Associates Chicago, July 27, 1945

applies to the worker instead of the job, his earnings in the situation just described will be as follows, assuming that his hourly rate is \$1 00 per hour, *SR*, or 9 × \$1 00 = \$9 00 The plan is simpler where the rate applies to the worker instead of a job This plan has an advantage over straight piece work in the event of raising or lowering the base rates The standard times remain the same, and the only change required is the hourly rate This simplifies the record-keeping problem in case of changes and possibly has certain psychological advantages

The 100 per cent time premium plan is equivalent to the straight piecework wage program having a guaranteed day rate with time instead of number of pieces as the unit of payment It is also a modification of day rate based on production, as described on p 25 2 The result is identical with the Bedaux plan when the worker is given the full time saved, on the assumption, of course, that the standard task is the same for both systems It is possible under the plan to give recognition to a worker's length of service by raising his hourly rate When this is done, the 100 per cent time premium plan embraces many of the characteristics of the measured-day work plan

26 SPECIAL FORMS OF WAGE PAYMENTS

Group payments Most of the various incentive plans can be used in paying groups Since but one premium or bonus need be figured for each group involved, the amount of clerical labor is somewhat reduced Group payments may also be used to reward foremen and other supervisors by including them in the group or departmental unit that is subject to the bonus Group payments aid management in checking the efficiency of groups, departments, and the plant as a whole from day to day Group payments are of greatest value when the workers are operating on assembly lines or on a series of operations where each worker's output is dependent upon the productivity of the other members of the group Group payments have been used for entire departments and workers not associated with each other

Advantages of group payments Group payments to workers have sociological as well as economic advantages [1] Group payments are presumed to promote worker cooperation Indirect workers, even janitors and other laborers, when included in a producing group may develop a sense of responsibility for production and cooperate effectively to this end Group bonuses will usually work to advantage when a given operation is performed by several persons whose individual efforts are inseparable for wage-payment purposes, but they will not always succeed when applied to whole departments It is probable that the relative ease of setting bonuses by groups does not compensate for the inaccuracies which occur Under such conditions bonuses may preferably be paid on an individual basis Group payments are not suited to all conditions If the jobs are entirely unrelated, it may be that the spurring action of one employee on another will not be so effective as anticipated, and under such conditions poor operators will profit from the better than average work of the best men Under some conditions the best workers will feel that an unfair advantage has been taken of them by figuring their wages partly on the efforts of inferior workmen

[1] See F J Roethlisberger, William J Dickson, and Harold A Wright, *Management and Morale*, Harvard University Press, Cambridge, 1946, pp 263–264, for an interesting discussion of this subject

Group payments facilitate the breaking of "bottlenecks" The slow operations are assigned to the fastest men in the group, and thus all the help necessary is given to obtain the maximum production There are "tricks of the trade" in every operation, and when several workmen are involved the best and fastest methods are worked out in very short time by the group members A group bonus, because it makes one worker desire to help another, results in developing all-round men This is important when production must be decreased, for, by reducing the number of men in the group, production is cut automatically

Disadvantages of group payments Rate cutting is just as easy with the group bonus as with any other type of wage payment *Most disadvantages are not inherent in the system of group-bonus payments as such but arise largely from the failure of management to perform its function properly* It is true that the payment of a group may offer management an excuse for its action, such a performance, however, seldom deceives anyone other than management itself The fact that some workers receive wages which are based partly on the output of others may engender ill feeling and backbiting Pegging of production is just as easy, or if anything easier, under group payments as under individual payments The lack of incentive arising from size is discussed below

The size of the group When the group is small enough so that each man can see the results of his individual efforts, the system functions more effectively A group ranging in number between 10 and 20 is most likely to respond to group effort The technology of the operation may dictate the group size The worker can see the results of his efforts more clearly in a group of 10 than in one of 20 The elimination of one worker from a group of 21 imposes an increase of 5 per cent on each of the remaining workers if they are to absorb the additional burden The elimination of one worker from a group of 11 results in an increase of 10 per cent to the remaining men under the same conditions When the worker sees his bonus increase 10 per cent, this means a great deal to him

Practically all groups of moderate size have a recognized informal leader and pace setter When the group is small enough for this leader to make his influence felt best results are secured Through its unofficial leader the group will exert pressure upon lazy members who are holding down the group earnings The influence of the worker leader diminishes rapidly when the group exceeds 20 men It is even more effective with a group smaller than 20

Rates for learners Even though the beginner may be given a relatively low day rate at first, he will often take from the group more than he contributes This situation, which is not conducive to his acceptance by the group, may be handled in different ways In some cases the learner does

not share in the bonus for a short period, after which he is placed in the regular group In other cases he does not share the bonus until he has reached or nearly reached standard performance In other situations he is placed in the group from the beginning When the group is large, the addition of the learner does not pull down the earnings of the other members so much, but it becomes a real problem in smaller groups The solution usually consists of a compromise

The problem of paying the beginner applies to individual incentive systems as well as to any form of group payments One large manufacturer in the metalworking industry estimates that it costs the company $400 above the worker's contribution to production to train a worker The rate to be paid the beginner is not easily established from the standpoint of managerial cost predetermination and justice to the group and the learner The value of the beginner in terms of actual productivity is frequently very low for the first few days It naturally becomes relatively higher as experience is acquired

Supervisory bonuses Usually the production bonus that a foreman receives is directly proportional to the productivity of his department This is an essential feature of any foreman's bonus scheme In the Bedaux system it is easy to determine the number of "standard units" produced by a department and to give the foreman a bonus based on a previously determined scale Under the task and bonus scheme a foreman may receive a bonus based on the number of workers under him who are themselves receiving bonuses The foreman becomes directly concerned with the removal of all obstacles toward increased production, instead of leaving this problem to the higher executives or the methods men Foremen's bonuses can be worked out for any phase of the operation of their departments, for instance, quality, accident reduction, or methods improvements

Supervisory bonuses may be figured on a basis of all of the factors for which the supervisor is responsible In addition to his sharing in the bonus that his men may earn, he may also have a bonus related to controllable expenses, such as direct labor, supplies, perishable tools, scrap, and certain miscellaneous items[3] Supervisory bonuses that are within the possibility of attainment range all the way from 10 per cent to 25 per cent of the foreman's salary Bonuses are more effective when they are paid on a basis of a relatively short period, such as a month They are frequently paid on the basis of the ratio of actual departmental expense to standard departmental expense For instance, one company pays a bonus for performance above 90 per cent of standard but not to exceed 25 per cent of the base salary In order to prevent manipulation of expenses, at

[3] See Charles W Lytle, "Incentive Compensation for Foremen" American Management Association, *Production Series*, No 166, New York, 1946 pp 17–31

times a 3 months' average of premiums earned is paid instead of the premium for the latest months

The Eaton Manufacturing Company, Cleveland and Detroit, uses a supervisory bonus, which begins at 90 per cent efficiency in relation to attaining the budget, with a limit of 20 per cent of the supervisor's salary For instance, on the basis of a moving average for 3 months, a supervisor is paid a bonus of 5 6 per cent if his efficiency is 95 6 per cent If his efficiency is 112 per cent, his bonus will be 20 per cent The supervisors' budget includes direct labor, indirect labor, supplies, maintenance, scrap material, and tools A daily report to the foremen from the cost department serves as a strong stimulant to each foreman to watch his costs before they get out of hand The objective of the company in using the foreman's bonus is said to be

1 To reduce manufacturing expense

2 To "budget" such expenses on a "daily" flexible basis and to compare actual results with this budget

3 To encourage all levels of supervision to be expense-minded

4 To reward foremen for reduction in manufacturing expense by allowing them to share in the savings made

Quality bonus An adequate inspection system will ordinarily prove to be sufficient inducement to secure quality Bonuses for quality are more frequently found where quality, not quantity, is of paramount importance, although they are also used at times where quantity is desired Quality bonuses may be used with any wage system that has been discussed Quality bonuses divide themselves into two classes (1) those which are utilized where quantity bonuses are impossible, or at least impracticable, and (2) those which are used in conjunction with some form of quantity bonus to make a composite wage system in which the pressure on the worker will be toward both quantity and quality In the weaving of cloth, a bonus may be paid on the production which is secured from the loom, and another bonus may be paid if the defects which are discovered in a certain number of yards of cloth are kept below a certain number The relative amount of bonus to be paid for quantity and quality will vary with the importance of quality in the particular instance, for example, with the value per yard of the finished fabric

Attendance bonuses Attendance bonuses are seldom used save during periods of acute labor shortage During such times they are of value in increasing output, since they promote continuity of attendance by the working force and thus insure that any production program that is mapped out will not be hindered by lack of personnel to carry it through The promptness bonus is particularly advantageous in this respect, inasmuch as it usually results in almost uniformly prompt attendance throughout the

factory As a result the production department can know, soon after the factory doors open, what vacancies in the factory force must be filled in a given department on that day in order that production may be kept flowing smoothly Most executives object to an attendance bonus on the grounds that, when a person is hired, he is expected to be at the factory on all working days and to be there promptly Therefore an attendance bonus should be unnecessary and is an undesirable payment In times of slack production attendance bonuses are likely to be quickly eliminated

Attendance bonuses may be paid for attendance only, may include extra payment for promptness, or may be paid for promptness only Bonuses of this type are frequently paid in money but are sometimes given in the form of added days on vacation If the bonus is paid in money, the amount is not usually very large

Length-of-service bonuses The most frequent basis for recognizing length of service is additional vacation time Service is often recognized in profit-sharing bonuses (where profit sharing is an accepted policy) Some companies automatically raise hourly rates on a service basis until the rate reaches a midrange or even a maximum for a given classification Automatic raises of this type are really not designed to be bonuses in the true sense but are based on the time estimated to be required to become proficient on the job There is some question just how far a differential in the base earnings due to length of service should be carried Ordinarily a worker with 5 years' seniority doing as much or at times even more work than the 10-year man has difficulty recognizing the justice of paying the 10-year man more merely because of his length of service

Odd-shift bonuses Payment of some form of additional reward for working on the second or third shift has become the rule rather than the exception since World War II The increase of the basic rate for night work need in no way affect the operation of an incentive wage system, as the premium or bonus can be figured on the night base rate as easily as it can be figured on the day base rate Some of the plans for the payment of a bonus for night-shift work are (1) payment of a certain stipulated number of hours' pay per week in addition to the pay for the number of hours actually worked on the night shift for example, payment for 3 or 5 extra hours, or the workers may be paid for the lunch hour such as being paid for 8 hours even though only 7 5 hours are worked, (2) payment of a certain number of cents per hour worked on the night shift, as 5 cents per hour for the second shift and 7½ cents per hour for the third shift, (3) payment of a certain percentage of the day rate in addition to the day rate for odd-shift work, as 5 per cent and 10 per cent

Remunerating salesmen Incentives for increased productivity are found in sales work quite often Any commission or bonus plan is usually

coupled with a basic salary or drawing account Commission over straight salary is paid for sales above a minimum quota that has been set, and drawing accounts are paid back by the salesman through commissions earned, after which all commissions earned are his Many firms give salesmen bonuses for unusually good performance These bonuses may be paid in addition to the regular commission, or they may be used in connection with sales people who are primarily or entirely paid on a salary basis Bonuses are likely to be paid quarterly, semiannually, or annually, whereas commissions are usually paid at shorter intervals, frequently to correspond to the regular pay period Some companies offer salesmen a choice between a straight commission or a salary plus a lower commission This is especially likely to be true with beginning salesmen

Frequently the same salesman will receive different commission rates for selling different products at the same time A slow-moving product that seemingly is encountering considerable sales resistance may carry a larger commission than another article that is moved more readily The same product may carry a different commission to salesmen traveling in different territories, the higher rate being paid to the man in the territory less densely populated or less productive The commission for a sales person in department stores is sometimes adjusted to the seasons in order to maintain a more equitable wage Where this is the program, the commission for the slow period such as August is usually higher than for the month of December Advantages of the straight salary are somewhat greater in selling than in manufacturing industries The advantages claimed for the straight salary for salesmen are

1 Management may exert more direct control over the salesman's activities, such as sending him to any territory or part of his territory, or assigning him to special tasks or to selling special items
2 The plan is simple and easily understood
3 Record keeping is simplified
4 Security is given the salesman in that he knows what his earnings will be

The main advantages of the commission plan are listed below

1 A strong incentive for increased effort is provided
2 Flexibility to meet changing conditions is more readily achieved
3 Employees are paid largely in terms of results, which is the only truly equitable basis of payment The efficient salesman is not penalized, and the substandard one is not overpaid

In connection with the advantages of the commission form of payment, it will be observed that this method corrects the weak points in the salary system It is also true that the strong points of the salary basis of payment are the weaknesses in the commission plan

The ideal plan for paying salesmen would meet the following requisites

1 It would provide payment in terms of sales effort and accomplishment

2 It would provide security in that the salesman knows that he has an income at all times sufficiently high to meet his *minimum requirements*

3 It would provide a strong incentive for increased effort and accomplishments

4 It would be easily understood and would not entail excessive clerical costs

5 It would enable management to control the salesman's activities, to use him where he is most effective for the enterprise as a whole

6 It would be flexible enough to enable management to meet changing conditions as they arise

Executives' salaries Executives' salaries are of major concern to subordinates as well as to owners If the top executive's salary is low his subordinates will have relatively low salaries The salaries paid top executives are influential in determining the salaries of middle management and all the other members of the supervisory group Salaries of business executives tend to bear a geometrical ratio to those of their subordinates, not merely an arithmetical one While it is difficult to measure the specific contribution of an executive to profits, the performance of his company is in a large measure a reflection of his efficiency A chief executive who successfully directs an enterprise like General Motors is not overpaid if his base salary is $100,000 or more, with bonuses bringing the total to a half-million dollars On the other hand, a man with mediocre capacity would be very expensive to a corporation if he paid a million dollars annually for the privilege of being the chief executive

Competition plays a partial role in setting executives' salaries Others bid for the services of leaders of recognized ability Salaries must be high enough to hold men of superior business leadership, or else they will enter business for themselves in direct competition with their former employers It must ever be remembered that executives of demonstrated ability have little difficulty in securing financial backers The factors that may be taken into account in setting a scale for executives' salaries are the following education necessary, amount of business experience required, amount of specialized business experience needed, amount of administrative experience necessary, number of workers supervised, character of workers supervised, and amount of payroll supervised A table fitting the needs of a particular business can be worked out, with salary ranges within each step of the table Then the salary of an executive whose duties and qualifications fall within any step of the table is set on the basis of the salary specified in the table Changes in payroll affecting executives must usually be studied and approved by one of the major operating officials of the company, not by rate-setting or similar groups

Job evaluation has been applied to executives' salaries below the level of the senior executives This is an enlightened step toward rewarding middle managers according to the requirements of their positions

It is good practice to pay executives a *base salary* sufficiently large to cover their needs and the *rest of their salary* in the form of bonuses or profit sharing Such a program provides a strong incentive, makes them have a proprietary interest in the business, and does not saddle the enterprise with high fixed salary charges during periods of slack business Another form of partial executive remuneration is to provide adequate pensions on retirement This plan has the advantage of not requiring the executive to pay special attention to building up a personal estate for his retirement, thus enabling him to give undivided attention to his company duties Another advantage is that money paid into a pension fund is not taxed while the executive's earnings are high Income taxes are paid only when the pensions are received Frequently $100 paid into an executive's pension fund will net him more than will $200 paid to him as regular salary

PART 7 ______________ BUYING, SELLING, AND COST CONTROLS

27 THE SALES DEPARTMENT

The sales function In the terms of the economist, the selling function creates *possession utility* At times the sales force may control not only *possession utility* but also *place utility* Goods are not completely produced until they have been turned over to the ultimate consumer for his use In this sense the sales function is a very vital phase of production It should be clearly recognized that economic terminology is not the language of business The business man divides business functions into three broad areas, namely, production, finance, and sales

From 1929 to 1941 the selling function dominated American business We could produce a great deal more than we could sell During World War II and the years immediately following there was a shortage of goods and "order taking" supplanted real selling Such a period is known as a "sellers' market" Just before the outbreak of the Korean War a "buyers' market" began to emerge but soon gave way to the "sellers' market" arising from shortages induced by the war effort By the close of 1954 a "buyers' market" was again in full swing The sales department sets the pace for industry during a "buyers' market," which bids fair to be the dominant condition in business unless disturbed by another war

In our discussion of the control of sales there is thus assumed a sales or a merchandising manager having actual control over the means and methods of distribution, as well as responsibility to the general management of the business This sales manager, although full of enthusiasm and drive, and with the ability to go out and get business in the old-fashioned way, must also be cool and calculating and able to plan and direct the efforts of his subordinates, as well as to coordinate these efforts with those of the production and financial staffs

The sales organization A large corporation manufacturing a series of products that are distinct in certain major characteristics may be organized on a divisional basis according to the products In this event there may be no central sales office at all, or there may be a company sales manager who merely renders staff advice The General Motors Corporation is organized on such a divisional basis If a company is not

organized on a product basis, the sales department may be organized on a regional basis (sometimes called divisions) for control purposes. The over-all organization structure and philosophy influence the organization of the sales department. The actual organization of the sales force will be largely determined by the nature of the product, the desired market, the methods selected for demand creation, the distribution channels used, and various combinations of these factors.

While our major concern is with the sales department of an industrial enterprise, nevertheless an illustration from retailing will show how markedly different the selling functions may be. Two large department stores may follow different organizational principles even though they sell the same product. In one store the buyer may be in direct charge of the sales people, merchandise, and displays of his department, and in another store have no direct control over the salesmen. The advertising department in a toothpaste-manufacturing enterprise may report directly to the president and even have the sales department as a division of advertising, whereas advertising in most organizations is a department under the sales division. Sales promotion usually is a function performed by a department of the sales division. In some organizations it may be a separate department coordinate with the selling organization, and both may report to a common head who is a major executive.

Centralization vs. decentralization. In large enterprises having national distribution the question of home office control arises. If the branch managers have relatively little authority and have to receive approval from the central office for such items as credit and sales campaigns, they usually are lower paid, but the organization lacks flexibility and service suffers. If the branch managers operate within certain broad policies but otherwise as if they controlled independent concerns, the organization is more aggressive and flexible; this type of organization, however, requires a higher type of personnel and is more expensive. Usually the additional expense is justified unless the products are highly standardized. Frequently such items as advertising, accounting, and office procedures are controlled from the central office and the manager is given much latitude in the actual selling and in purely local matters.

Specialization. Segregation of the salesmen may develop from the fundamental characteristics of the buyers of the same article, or it may result from the differences in the nature of the products, or both. Taxicab-fleet owners, automobile manufacturers, and passenger-car owners buy automobile tires, yet the problems arising in selling to each group are distinctly different and can best be handled by specialists. The Nash-Kelvinator Corporation and the General Motors Corporation manufacture both automobiles and electric refrigerators. The technical problems involved

in selling these two products can best be cared for by specialists in each field However, where customers are few and are separated by great distances, the advantages of specialization may have to be dispensed with in the interest of economy in travelling expense Foreign trade usually presents so many special situations that they can best be cared for by a separate department or organization within an enterprise In some instances a separate corporation may be organized to carry on the foreign trade for the parent corporation The controlling principle in sales organization should be that the organizational structure is itself a means to an end The same business enterprise may wisely use a different structural organization of its sales force in different areas at the same time, or at different times in the same area

The organization should constantly be evaluated in terms of its reasonably current expectations and demands It should continue as a living entity coordinating the active interests of all concerned and not be a "hangover" from conditions that have long since ceased to exist Theoretically desirable sales organizations may well be created by specialists in this field, and it is desirable for the sales manager to have such programs before him as a goal to strive for As a matter of practical necessity, he must, however, use the available personnel and, temporarily at least, adjust the organization to the capacities of this personnel A planned training program will reduce the number of special adjustments that have to be made to the desired organization

The merchandising department Terminology is not standardized, but the merchandising department usually serves as a coordinating and analytical department primarily concerned with product design, standardization, simplification, and prices This department approaches product design from a commercial, not a technical, standpoint It strives to study consumer needs and style trends The merchandising division correlates suggestions for the product regardless of the source, studies means of improving the attractiveness and utility of the packaging, makes market surveys, issues catalogues and price lists, and acts as an intermediary between engineering, production, and sales [1] Where the merchandising department functions as outlined above, it is usually a division of the larger department of distribution The distribution department in such situations also has the direction of the sales department and the advertising department

The influence of the extent of the market and the nature of the product The nature of the product exerts a strong influence upon the organization of the sales force The methods used in marketing Oregon fruit differ materially from those used in marketing lumber or hardware

[1] See Paul E Holden, Lounsbury S Fish, and Hubert L Smith, *Top-Management Organization and Control*, McGraw-Hill, New York, 1951, pp 53–54, 178–184

There are two major classifications of goods, namely, *producer's* and *consumer's*, and each has its own special problems in marketing. Between these two classifications there are many gradations. The same product may be a *consumer's* good in one instance and a *producer's* good in another. When sold to the housewife, cloth is a *consumer's* good, whereas it is a *producer's* good when sold to the dress manufacturer. The selling organization must be so constructed that not only the nature of the product, but also the buying habits and customs of the purchasers, will be given due consideration.

The market may be confined not only to a single city but even to one sector of this city. The nature of the product may influence the decision, or the policy of distribution may be controlling. In some cases a manufacturer may decide to cultivate a given territory intensively, whereas in another situation the same manufacturer may conduct an extensive sales program. Within the same area a given manufacturer may cater to two or three different markets. In Chicago, for instance, a paint manufacturer may sell directly to the automobile producers and governmental units and through retailers to contractors and to householders. Each of the three markets may require special salesmen, a fact which will definitely influence the organization of the sales force. The custom that has grown up in a given industry may also influence the organization of the sales force and the method of distribution. If the market for the product is national, the organization of the sales force will have to be adjusted to this situation. On the other hand, a product may by its nature be restricted to a local market and thus require a different type of selling organization. The difference in the organization may not arise out of the difference in the size of the sales force, although this may be a factor. For instance, ice cream is usually sold in a local market, whereas files and glue generally have national distribution. An ice cream manufacturer in Chicago may have 10 or 15 salesmen and a national distributor of files may have the same number, each firm performing a satisfactory service in its respective field.

Channels of distribution. Certain products require specialized knowledge to demonstrate and sell. The ordinary retail outlet is seldom in a position to give this specialized service. Machine-tool manufacturers have often found the mill-supply houses unsatisfactory as outlets for their products and have sought to deal directly with the users of their equipment, although this is usually an expensive method of distribution. Staple products are successfully marketed through the regular retail outlets. A large manufacturer of several products may utilize many different outlets. In one area he may sell through wholesalers and jobbers and in another through his own branches and warehouses, whereas in still another region he may offer a product through chain stores. Here again such factors as

the financial resources of the company, custom, the extent of the market, the nature of the product, and the special inclinations of the management may be controlling Both the nature of the product and the market that is desired definitely influence the organization of the sales department and the choice of the distribution channel

Sales promotion involves such items as the use of personal salesmen, selling through correspondence, the use of samples, the use of advertising, and the medium to be used for advertising These methods may be used singly or in any combination The actual methods used directly influence the organization of the sales department Mail-order selling or selling by correspondence requires a distinctly different selling organization from that used in house-to-house canvassing If large-scale advertising is used, a special advertising department or the employment of an outside advertising agency will be necessary When an outside agency is hired, provision must be made within the employing organization to approve the advertising in a general way, at least to see that it conforms to the over-all objectives and policies of the enterprise

Price determination The sales price is influenced by many factors, a few of which are (1) whether the company has a monopoly or is in a competitive position, (2) whether to "charge what the traffic will bear" or to determine price on the basis of cost of production, (3) whether large volume with low unit profit or relatively small volume with high unit profit is desired, (4) whether the demand for the product is elastic and whether substitutes, actual or potential, threaten the market, and (5) what the short-run competitive price in the given market is In the absence of a monopoly competition will usually tend to reduce high unit profit In an effort to maintain a semimonopolistic position, a company may engage in intensive advertising Although intensive national advertising by radio, magazines, newspapers, billboards, and other media may not give a technically monopolistic advantage, in substance it approaches this result, for only those organizations having tremendous capital available can successfully enter the field This situation is well illustrated by the toothpaste manufacturers Relatively few articles have an inelastic demand Acceptable substitutes are available for most products when prices get out of line In the short-run a manufacturer may be forced to sell his product at a price somewhat less than that necessary to recover all costs, particularly during certain periods of the business cycle Price determination is not solely a function of the sales department In determining basic policies, the board of directors may elect to produce a high-quality product to be sold to a restricted market on the basis of a relatively high unit profit The ultimate long-run price is usually a compromise between external influences and the many interests of the internal organizations

From the customer's standpoint service provided by the manufacturer is closely related to price One manufacturer may give free service for a period of 3 months to 1 year Naturally, payment for this service must be included in the original selling price Another manufacturer may operate his service department as a convenience to his customers and a part of his advertising program, charging the customer the actual cost, in some instances not including overhead and in others including all determinable costs Still a third controlling philosophy is used by other manufacturers, namely, to charge for service not the actual cost but an amount sufficiently high to give a profit Again, there may be various combinations of the foregoing policies, such as providing free service for the first 3 months and then setting charges that will make a profit on the operation of the service department as a whole

Credit control If the enterprise does a strictly cash business, the necessity for a credit department is eliminated, likewise, much of the record keeping is reduced In some organizations the credit department answers directly to the treasurer, whereas in other concerns it may be a functional unit of the sales department Selling on credit, even on open accounts, involves additional burdens of investigation, billing, and follow-up of collections as well as computations of discounts for cash or payments within a specified period, such as 10 days Such a sales program ties up additional funds and thus influences the amount of money required for a given volume of business Either system, selling for cash or on credit, directly influences the organizational structure of the enterprise

The sales manager In addition to being skilled in the techniques and procedures of selling his product, the sales manager is primarily an executive directing the activities of others The sales manager is aided in his search for new products or new uses for his present products by the technical research staff and the merchandising department In addition to providing the consuming public with what it wants when it wants it, the sales manager is faced with constant pressure from the producing organization to aid in reducing seasonal variations These considerations are important whether the company manufactures primarily to schedule or primarily to customers' orders If the latter plan of operation is followed, the principal difference is that the sales manager's task is much more difficult, in that he has to sell and plan for sales in terms of the extent to which current orders fill particular portions of manufacturing capacity Delivery dates on new orders that are taken must then dovetail with promises that have been made on orders already turned over to the production departments for manufacture If the plan provides for the manufacturing of standard products to schedule, the control of sales becomes somewhat simpler, although the energies of the sales force must frequently be di-

rected toward the movement of certain articles which the market suddenly rejected after the budget and the manufacturing program were developed The energies of the sales manager, in addition to his constant drive to sell what is being produced or what will be produced, are partly occupied with thoughts of new lines of products to be developed

Planning the sales program Planning for sales is predicated on the idea that the sales manager must act strictly on facts, must carefully determine these facts, and must supervise his force in a way that will bring measured results from these facts The details of the sales plan will be influenced by the decisions reached after due consideration of the factors discussed earlier in this chapter (1) analysis of the nature of the product, (2) analysis of the market to be reached, (3) distribution channels, (4) organization of the sales force, (5) price of article and credit terms

Salesmen easily fall into the habit of neglecting outlets which they do not happen to like Some means must therefore be provided of checking calls against route lists which have been provided for them Some firms provide an exact schedule for their salesmen, detailing precisely what calls shall be made on specific days and demanding an adequate explanation of failure to make expected calls One large house-to-house distributor of food products boasts that it can tell just where any one of its 1600 salesmen is at any time and not be in error greater than a distance that can be travelled in a half hour Although it is frequently advisable to schedule the salesman's program much more in detail than was formerly the practice, he should be allowed considerable freedom to adjust this schedule as occasion demands Errors usually arise because of schedules being controlled by a clerk who is not familiar with operating conditions Although a clerk may do the paper work even better than a sales manager, when questions of judgment arise, decisions should not be left to a clerk The sales manager may travel into difficult or highly competitive territory and lend a helping hand to his salesmen Special awards, bonuses, and contests for salesmen have real significance if sales have been previously planned The sales manager will find that through these aids he will have the concerted effort of the whole sales force directed towards the fulfillment of the sales promises which have been made to the general management and the other operating departments

Establishing the sales quota Although quotas must be fairly well worked out before the sales estimates are submitted for budget-making purposes, they will have to be revised after the adoption of the budget to insure that its schedules are attained Quotas must be set with the basic factors within the territory in mind Inaccessible population cannot be counted Some knowledge of trade customs within the territory is involved in this question With goods which are sold for household purposes such

factors as the strength of mail-order houses must be taken into account, and the nature of transportation facilities must be considered. With products which are used largely in trades or in manufacture, the usual channels of purchase must be thoroughly studied. The only population of value is that which may properly be expected to be in the market for the product. Thus, if quotas are being set on shirts retailing at $6.50, the available population is reduced considerably under that which must be considered in setting quotas on shirts which sell for $4.50. Crude population statistics are, therefore, of little value in setting quotas, although they may be utilized as a point from which to start.

The number of outlets must be determined. This may be the number of dealers or in some cases the number of direct users of a product. Thus, the quota of a branch sales office of an automobile-accessory manufacturer located in Detroit will necessarily be higher than the quota of the Cleveland branch. The volume of prior sales must be given some consideration, as must the extent of competition within the particular territory. Scarcity of potential buyers may run up the cost of sales to the point where it may be desirable to abandon certain territories, such as the sparsely populated areas of Nevada. The relative advertising expenditures in comparison with those of competitors must be taken into account. Market conditions within a territory should affect the quota set for it. Thus crop failures in a farming area must affect the quota set for the community the next year for nearly all products. New sales efforts may affect all quotas equally, or they may affect some to a greater extent than others. If intensive advertising campaigns are to be run in certain sections, the quotas for those sections must be advanced correspondingly, as the salesman and dealer aid from this source will be considerable.

Sales promotion. In large companies sales-promotional work can, in its routine aspects, be handled in the main by a sales-promotion department, operating only under the general direction of the person in major charge of distribution. However, the sales manager will be forced to lay out the major lines of operation for the sales-promotion department, if he is to correlate the work closely with that of his own direct assistants and with the administrative program which has been laid down for the company as a whole. The sales-promotion department must be in constant touch with the salesmen or distributing agencies which actually sell the product and must be in a position to aid them to push a certain article in the manner which may seem most effective at any particular time. The control of advertising campaigns and appropriations may be placed under such a department, although the actual preparation of advertisements and direct contacts with publications or printers are often left in the hands of an advertising department or with an advertising agency. A sales-promo-

tion department should know the customers and the trade thoroughly In addition, it should be completely familiar with the products that are being manufactured Through the head of sales, it knows the programs which have been laid down for a forthcoming period, and with all these factors in mind it constantly strives to promote the realization of the developed sales program

The sales-promotion department gives the salesmen the home-office aid that is necessary when and where it is necessary, and in so doing it cooperates directly with the sales manager or whoever else is in direct charge of the salesmen It maintains a stock of the various "dealers' helps" which have been devised and distributes them to dealers in a way that will promote any particular campaign or program that has been determined upon

Analyzing the sales results A careful study of the monthly comparisons of actual sales against the sales budget frequently reveals errors in either the budget or the sales plan The keeping of accurate sales records and careful planning in the light of organized experience distinguish the modern sales executive from the so-called "star salesman," who is frequently strong in performance but weak in coordinating and directing the efforts of others Territories which have proved to be unprofitable must be given up Territories which cannot be adequately covered by one man or which might be better handled by another branch should be adjusted to fit ascertained conditions Careful study of campaigns which have been previously planned will give satisfactory information for changes that affect subsequent campaigns The sales manager is enabled, after he has established the control which has been outlined, to cooperate more intelligently with the production executives, to determine accurately his best salesmen and the best branches, and to reward them accordingly

Selecting, training, and maintaining the sales force The sales manager should use the services of the employment manager in sorting, initial interviewing, and possibly testing all applicants for selling positions The sales manager may prefer to do the final passing on candidates referred to him by the employment manager The qualifications desired in a salesman are determined largely by the particular sales task to be performed Some products require technically trained men to sell them successfully Certain types of experience have been found in other cases to provide a desirable background for selling special products The man who has made a success of selling taps, dies, and abrasives has been found by hacksaw and file manufacturers to be a likely prospect as a salesman of their products The factory and service departments frequently provide excellent men for the sales group Such employees are already known to the management, are familiar with company policies, and require a shorter training period

The training program should be adjusted to the needs of the particular enterprise The understudy system, after an intensive training period in the factory, is used extensively for travelling salesmen In department stores the sponsor system is frequently used Some organizations have regular sales courses through which they put all new salesmen Another phase of the training program is the "in-service training" This program is particularly difficult when salesmen are operating far from the home office Under such conditions there are two basic problems One is to keep the salesman informed regarding the improvements in his product, and the other is to keep him enthusiastic concerning the policies of his company Correspondence courses especially designed to acquaint the salesman with his products, special sales helps pointing out technical developments and new sales methods, and regional or home-office conferences are the common methods of training field salesmen If the sales people are under one roof or within a given area, the sales conference is most successful, even though sales helps may be used

Although a really successful salesman appears to adapt himself to whatever conditions he meets, buyer resistance is reduced by properly apportioning territories among the sales force A salesman must be selected for a particular territory with a view to the buyer resistance or acceptance within the territory Polished salesmen may succeed in one place, whereas rough and ready salesmen will succeed in another Enthusiasm of salesmen in attaining sales goals can be stimulated by the methods of payment If both a salary and commission are paid, the two methods must be balanced so as to be most effective Commissions should be based partially on the success of the salesman in reaching quotas which have been established for him In other words, compensation must be based on production, and production in turn must be determined in relation to a set task and quota This task or quota may vary with the product, with the territory, or with the salesman A properly constructed plan of compensation is an aid in holding the new salesman and serves as a strong incentive for the experienced man The most successful salesmen are highly individualistic and readily develop a partnership attitude toward their companies, particularly when their reward is directly related to their effort

28 · THE PURCHASING DEPARTMENT

The location of the purchasing department in the organization Regardless of the position of the purchasing department in the factory, some means should always be provided for keeping the head of that department closely in touch with all conditions that may influence the course of his daily task, at least in the immediate future In the main in a modern organization the purchasing agent works toward the quality specified by the engineering or design department and the quantity specified by the production or planning organization Most purchases will originate through the inventory control that is maintained at the balance-of-stores desk, and this control will usually be exercised from the planning department Decisions must be continually made whether to buy or make a certain part The answer in any given case is likely to be influenced by the state of the market at the time and the manufacturing conditions in the shop, both in regard to the need for the product and the possibility of putting it through production and in regard to the desire to build up outside sources of supply to fill future needs General executives sometimes feel that they are the only ones who can decide such questions If the purchasing agent is competent and if a committee organization with a main factory committee is provided, such matters form an excellent subject for decision by these persons The purchasing agent can be advised under such circumstances by the factory and design representatives who may be present

If the product is standard, the scope of the purchasing agent's authority usually has been so limited by those who drew up the specifications that his task is fairly simple and, therefore, one that is subject to general manufacturing control If the product is not standard, the purchasing agent usually must decide many matters concerning the purchase of material which would not come within his jurisdiction with a standard product Hence his position within the organization will be correspondingly increased in authority and importance Tables 28 1 and 28 2 show the location of the purchasing department in a substantial number of plants

Occasionally purchasing is directly subsidiary to selling, or at least they go hand in hand Such a situation always exists in a manufacturing concern where there is a quick turnover of all raw material that is purchased,

with only a slight manufacturing process to be performed This frequently occurs in markets which are highly organized, such as the cotton or flour market In these cases and others, where "hedging" is carried on as a protection from loss, it is practically essential that the sales and purchasing phases of the business be under the same direct control Of course, this

Table 28 1 Location of Purchasing Department (by Percentages) in Concerns with a Single Plant or Localized Plants *

Size of Organization	President	General or Plant Manager etc	Vice-President	Treasurer	Secretary	Executive Committee	Comptroller
Small	38	32	17	6		3	4
Medium	38	27	20	12	2	1	
Large	17	50	17		16		
All reporting with single plant or local plants	37	30	18	9	2	2	2

* Courtesy National Association of Purchasing Agents *Handbook of Purchasing Policies and Procedures* New York 1939 Vol 1 p 4

Table 28 2 Location of Purchasing Department (by Percentages) in Concerns with Scattered Plants *

Size of Organization	President	General or Plant Manager etc	Vice-President	Treasurer	Secretary	Executive Committee	Comptroller
Small	26	37	21	10		6	
Medium	34	21	41	1		3	
Large	50	17	25			8	
All reporting with scattered plants	36	23	33	3	0	5	0
All reporting	37	27	25	6	1	3	1

* Courtesy, National Association of Purchasing Agents *Handbook of Purchasing Policies and Procedures* New York 1939, Vol 1 p 4

does not apply to the purchasing of supplies An example of such a situation is to be found in the business of mercerizing cotton yarns, where the yarns are frequently bought and sold within a few minutes' time, and the mercerizing process, which is all that is performed by the plant, adds but little to the value of the product There are many other types of business in which the manufacturing operations are more involved and relatively more important, but in which the position of the purchasing department is of maximum importance These businesses include most of the needle trades which purchase expensive fabrics, such as the men's clothing industry In this type of business a very large share of the profit made dur-

ing the year is derived from purchases at the right time or of exactly the right materials Thus the cost of the material purchased is an important consideration in the authority granted the department

The functions of the purchasing department The primary function of the purchasing department is *to provide the business with the required material and supplies when and where needed at a price consistent with the prevailing business conditions* The direct economic contributions of the purchasing department are *place utility* and *possession utility,* however, these are closely related to *time utility,* since the materials must be on hand when needed The major objectives of the purchasing department may be summarized as follows

1 To provide necessary materials, supplies, and services of the quality and kind required and at the time when needed

2 To secure these items at the lowest possible cost consistent with sound business practice and ethical procedure

3 To advise management regarding the possibilities of economies to be secured by manufacturing an item rather than purchasing it, or, in other instances, by buying rather than manufacturing

To carry out these major objectives, the purchasing department is required to perform more detailed functions, as follows

1 To interview salesmen regardless of whether an immediate purchase is contemplated, thus maintaining one of the important public contacts

2 To formulate specifications or at least to cooperate in their final determination

3 To secure quotations on the major purchases, compare these quotations, and place the order in keeping with the policies of the organization

4 To purchase directly all small items not requiring a quotation or bid

5 To formulate interdepartmental policies and to participate in the formulation of company policies pertaining to purchasing and public relations that influence purchasing

6 To inspect (or to see that inspection is carried out if it is performed by another department) all purchases for quality and count

7 To follow up all purchases to see that delivery is made when promised

8 To approve all invoices for payment

9 To be on the alert for new developments either in processes or in materials and to call them to the attention of the major executives charged with the specific responsibilities involved

10 To maintain adequate records of sources of supply and the nature and reliability of each source

11 To study economic trends in the market for specific commodities as well as business in general

All of the activities listed above may not be located in the purchasing department For example, the keeping of inventories at a minimum consistent with production requirements is a function of the purchasing department in many institutions, although this responsibility frequently is

placed upon the stores department, the production-control department, or some other department

Purchasing agents have developed a highly professional outlook in their association, The National Association of Purchasing Agents This Association's "Principles and Standards of Purchasing Practice" as listed below constitute a practical operating code of ethics

1 To consider, first, the interests of his company in all transactions and to carry out and believe in its established policies

2 To be receptive to competent counsel from his colleagues and to be guided by such counsel without impairing the dignity and responsibility of his office

3 To buy without prejudice, seeking to obtain the maximum ultimate value for each dollar of expenditure

4 To strive consistently for knowledge of the materials and processes of manufacture, and to establish practical methods for the conduct of his office

5 To subscribe to and work for honesty and truth in buying and selling, and to denounce all forms and manifestations of commercial bribery

6 To accord a prompt and courteous reception, so far as conditions will permit, to all who call on a legitimate business mission

7 To respect his obligations and to require that obligations to him and to his concern be respected, consistent with good business practice

8 To avoid sharp practice

9 To counsel and assist fellow purchasing agents in the performance of their duties, whenever occasion permits

10 To co-operate with all organizations and individuals engaged in activities designed to enhance the development and standing of purchasing

Organization within the purchasing department The organization of any department *should grow out of the function to be performed* Frequently personalities control the organization structure rather than the function to be performed A strong master mechanic may buy not only his machinery but the supplies as well There is good reason for him to specify certain qualities desired or even specific products, but there is little justification for his spending valuable time purchasing materials the specifications of which have already been determined This does not mean that he should never see salesmen with new products unfamiliar to him Sound purchasing practice will bring the master mechanic into all decisions involving technical matters concerning which he is particularly qualified To have purchasing carried on by every man who has a special interest violates the fundamental principle of functionalization Purchasing by department heads usually results in payment of a higher price than is necessary and frequently is conducive to the placing of orders more on the basis of personal likes and dislikes than on the merits of competing products Such practices may readily lead to direct or indirect bribery Centralizing purchasing in the purchasing department will not eliminate the temptation to accept bribes, but it reduces the number of places in which this practice

is possible Purchasing involves much clerical detail that is usually distasteful to most department heads, who tend to neglect it when they do the purchasing

At the head of the purchasing department is usually a purchasing agent He may answer to the president or, in larger organizations, to a purchasing committee His title may be vice-president in charge of purchasing, director of purchases, purchasing agent, or something similar In medium-sized organizations the purchasing officer may occupy the same high position that he holds in the large organizations, however, he more frequently

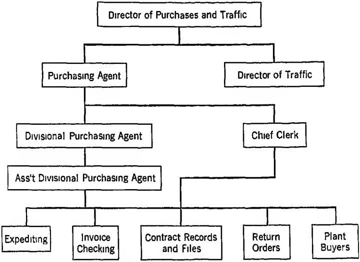


FIG 28 1 Organization chart of a purchasing department

reports to the general manager As organizations decrease in size, the purchasing department tends to be placed in a relatively less important position It is not infrequent in the smaller organizations to combine purchasing and stores keeping In smaller organizations there will usually be only one buyer, who may divide his time with some other duty With the increased size of organizations, more people are needed in the purchasing department In the larger purchasing departments a high degree of functionalization takes place Such organizations usually have a purchasing agent, assistant purchasing agent, buyers, file and record clerks, stenographers and typists, traffic division, follow-up division, and materials engineer, in accordance with the size and magnitude of the work performed Where the volume justifies specialization, one buyer will purchase certain materials and another buyer something else The purchasing department is a staff department itself but usually is organized on a line basis within

the department Figures 28 1 and 28 2 illustrate two general types of purchasing organizations In Fig 28 1 receiving, stores, salvage, and inspection of incoming material come under the purchasing department In Fig 28 2 the purchasing agent directs only the buying and the clerical details

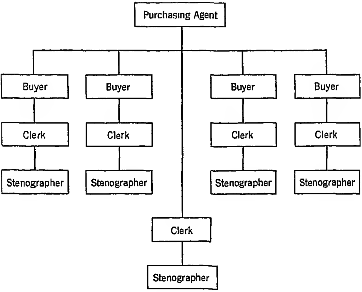


FIG 28 2 Organization chart of the purchasing department of a glassware manufacturer

pertaining to the buying Inspection, receiving, stores keeping, and similar activities are handled by the operating departments The author knows of one large metalworking company having six plants that has production

Table 28 3 Source (by Percentages) of Initiation of Purchase Requisitions *

Size of Organization	Department Heads	Storeroom	Production Department	Superintendent	Executive	Purchasing Agent
Small	66		17	17		
Medium	56	21	9	8	5	1
Large	64	23	8	2	2	1
All reporting	62	21	9	4	3	1

* Courtesy, National Association of Purchasing Agents, *Handbook of Purchasing Policies and Procedures*, New York, 1939, Vol 2, p 4

control under the purchasing department in addition to the divisions shown in Fig 28 1 This setup is unusual, but it is a manifestation of the influence of personalities In this company the purchasing agent is a vice-president

Table 28 3 shows the distribution of the source of requisitions It will be observed that the purchasing agent initiates very few requisitions

Centralized vs decentralized purchasing in multi-plant operations General Motors has popularized the phrase, "decentralized responsibility with coordinated control" It is the policy of General Motors to buy centrally those major items which can best be purchased by the parent organization When these items are not centrally purchased, they usually are bought by the main purchasing unit of the divisions Many of the divisions have two or more plants, and the less important items frequently are purchased by the local plant when this is advantageous The same situation is found in the big rubber companies For instance, it would be absurd for each of the plants of the United States Rubber Company to buy its crude rubber independently Similarly, to buy compounding ingredients and fabric independently would most certainly involve inventories in excess of need, and the prices paid by each unit would tend to be greater than the price paid by the central purchasing department A higher degree of specialization in purchasing is possible when buying is done centrally than when many different buyers are purchasing the same item in many locations Central purchasing also facilitates the transfer of excess stocks of a material from one plant to another Better financial control is exercised when the major items are purchased centrally Coordination may be maintained by having the central purchasing department prescribe the general routine and procedures but permit the local unit to exercise discretion in purely local matters Where necessary or advantageous, all bills may be sent to the central purchasing department, where they are checked and approved for payment by a central agency This practice frequently involves extra clerical work and expense No fixed rule for satisfactory purchasing is applicable to all organizations Purchasing, like other functions of a business enterprise, must remain flexible in order to meet changing conditions

Authority to purchase The authority of the purchasing department over finances must be limited This department should be operated on some sort of budget system, whether or not this system has been adopted for the company as a whole To require that all purchases be approved by the financial management of the concern too seriously limits the operation of the purchasing department, but to allow this department to purchase regardless of the condition of the finances is manifestly impossible The most effective means of controlling the financial end of purchasing is

through the operation of a general budget However, if there is no general budget, very effective purchasing budgets may be set up which will prevent inventories from mounting through improper purchasing operations or through mistakes in running balance-of-stores sheets Sometimes, if a product is standard, the purchasing department is allowed to buy on the basis of the normal consumption for a given period, for instance, 3 months After this point further purchases can be made only on an allotment of additional funds from the financial department

Often the purchasing department purchases only on order of the production control or stores departments In unstandardized lines it is almost a necessity to control purchase ordering to the production-control department or in some cases to the engineering department for highly technical items

Purchasing policies An active purchasing agent should participate in the formulation of purchasing policies and may initiate many of them Such decisions as whether to operate on a purchasing budget, to buy or to manufacture a given article, to engage in speculative purchasing or hand-to-mouth buying, or to substitute one material for another involve other departments and cannot safely be made except through the cooperative effort of the major executives concerned Certain other matters, such as whether to ask for competitive bids, to place the order with the lowest bidder, or to divide a large order even though one supplier may be able to fill it, involve borderline decisions and may or may not be left to the discretion of the purchasing department A properly organized department, however, may well make these decisions The internal organization of the purchasing department, in keeping with the organization structure of the enterprise as a whole, may well be left to the department head

Reciprocal buying refers to the practice of buying a given product because the vendor also buys the product made by the purchasing agent's firm It is the old game of "You scratch my back and I'll scratch yours" and is completely obnoxious to the capable purchasing agent During periods of prosperity reciprocal buying recedes into the background When sales are hard to make, pressure is frequently exerted to get the purchasing agent to "remember that we are one of your best customers" There is, of course, no criticism of the purchase of a product from a customer when his price is right and his product is the one desired Under these circumstances the purchase would be made even though the vendor were not a customer This is straight purchasing on merit and is not classified as reciprocal purchasing

Hand-to-mouth purchasing Hand-to-mouth buying is a sound business procedure when not carried to excess The practice has both social and

economic advantages and disadvantages Some of the *advantages* claimed are as follows

1 Hand-to-mouth buying reduces the inventory of materials on hand and releases the capital that would be tied up for other productive purposes

2 Storage facilities, storage costs, and handling costs are reduced when deliveries are timed so that the material may go directly to production (One purchasing agent for an automobile manufacturer boasted that his materials came in the receiving door and did not stop until they came off the assembly line as part of the finished car)

3 The budgetary requirements of production are more easily synchronized with purchasing

4 The buyer and the seller have more frequent contacts and thus are able to work more closely together to the mutual advantage of both

5 Losses arising from a decline in price are minimized by the buyer (On the other hand, he may pay a higher price for his annual consumption during a period of rising prices)

6 The buyer is in a position to take advantage of any favorable situation arising in the current market

7 The buying organization is in a more flexible situation in that it may make changes in the design and nature of its product or adopt new or substitute materials more readily

8 Hand-to-mouth buying should tend to level out production, since the producers have a better check on requirements than when the consumers buy in quantities and store a large part of their requirements (This claim is true only in part, depending somewhat on the product Since the practice has been adopted by the householder in buying coal, it has tended to increase the seasonal fluctuation because the producer cannot store his coal in the summer, nor can the coal yards absorb all the storage)

A few of the *disadvantages* of hand-to-mouth buying are

1 The producers are required to keep larger inventories, since the buyers rely upon the producers to carry the reserve inventories for them (The grand total social or economic inventories are less, but the producer's inventories are greater)

2 Unit purchasing costs on the hand to-mouth basis are higher because of the failure to take advantage of quantity discounts

3 Distribution costs are higher because of (a) a larger number of sales to accomplish the same results—the actual cost of making a large sale is very little, if any, greater than for a small one, and (b) increased packaging cost, order filling cost, and transportation cost when in less than carload lots

4 In some instances seasonal peaks and valleys are increased

5 The buying public, the consuming citizens, do not usually get such good service when the manufacturer of the original articles carries the inventories, especially when the retailers also buy on a hand-to-mouth basis Often the manufacturer cannot take care of sudden increases in demand, for his inventories are not large enough to absorb this increase Where buying for stock is more general, the grand total inventory in existence is greater, and consumer demand can be met more readily

Maximum and minimum stock-ordering points may be increased during periods of rising demand and lowered during periods of relatively slow or decreasing demand This statement does not imply speculative buying

When a budget is being used, an anticipated requirement for 3 months may reasonably be determined The full amount may not be bought at once, but purchases will certainly not approach the hand-to-mouth basis Larger orders may be placed with provisions for price adjustment in case of a decline and shipping instructions to be issued as required Such a procedure has advantages for both buyer and seller in the long run Both *hand-to-mouth buying* and *buying for stock* may be used, depending on general business conditions

Purchasing Methods One of the most widely quoted classifications of the different methods of purchasing is that of the late L P Alford It is as follows

1 Purchasing strictly by requirement
2 Purchasing for a specified future period
3 Market purchasing
4 Speculative purchasing
5 Contract purchasing
6 Group purchasing of small items
7 Scheduled purchasing [1]

To purchase by *requirement* is to purchase only when needed and in quantities needed Such goods as are purchased by requirement are usually not purchased regularly but are bought to meet a specific need The outstanding function of the purchasing department in this type of buying is to know the resources of reliable firms Supplies are often bought for *specified future periods* These items are standardized products that are bought regularly but in relatively small quantities The period covered by such purchasing is not fixed even for the same general class of materials Operating conditions, quantities required, and the same basic factors that influence other types of purchasing are controlling *Market purchasing* involves careful study of general market trends and the purchase of materials that are required in the light of reasonable market expectations Utilities and manufacturing enterprises that can predict their requirements with reasonable certainty may safely engage in market purchasing and still not be directly involved in speculative purchasing Raw materials such as rubber, coal, coke, and pig-iron are frequently purchased on this basis Market purchasing is definitely associated with planned production schedules, whereas speculative purchasing gives less attention to production requirements and is based largely upon expected changes in the market price

In reality speculative buying is a business within itself and may saddle production with costs that the producing group has no method of meeting

[1] L P Alford, *Cost and Production Handbook*, Ronald Press, New York, 1937, p 360

Obsolescence, demand for excess storage space and handling, and uncertainty as to available material when needed are among the problems that the manufacturing group must contend with when speculative buying is the practice *Speculative purchasing* is engaged in extensively by manufacturers or users of cotton cloth and also in recent years by users of silver It is not unusual to have the major profit arise from speculative buying The corollary, of course, is that production operations may be efficient, yet losses may be sustained because of errors in judgment in speculative purchasing A major executive usually directs speculative buying *Contract purchasing* is the purchasing under contract, usually formal, of needed materials, the delivery of which is frequently spread over a period of time Under circumstances when prices are uncertain, coal and steel have been purchased on this basis with a variable price per ton, depending upon the wage paid the workers, inserted in the contract Such provisions are not usually included in such contracts, however, because they defeat one of the major advantages from the buyer's standpoint, namely, taking advantage of low market prices to contract for requirements for a specified period *Group purchasing* seeks to take advantage of the savings that naturally accrue through placing one order for a number of small items rather than placing a large number of small orders Group purchasing reduces the cost to the buyer by eliminating much clerical work and also saves the vendor a great deal of clerical detail and delivery costs The balance-of-stores clerk or other person placing requisitions with the purchasing department can be of real service in grouping these requisitions The purchasing department should re-examine group purchases from time to time to make certain that particular items should be included

Scheduled purchasing is closely related to carefully controlled production It extends to the vendors some of the advantages of production control within the plant and thus enables them to plan their production and control their quality more effectively Scheduled purchasing tends to reduce the inventories carried by the buyer and permits the vendor to control his inventories more closely, since he is not placed in the position of having to meet unexpected demands Scheduled buying requires good faith and active cooperation on the part of both buyer and seller

Purchasing specifications Specifications are most essential, if the product is to be standard and if bids are to be asked for and compared Much of the secret of good purchasing lies in drawing good specifications which vendors must meet This practice is a real money-saver, because it prevents a concern from paying for a brand or trademark name which has been built up at high advertising cost, when the same article can be purchased elsewhere at less cost In addition, purchases may be made on a level of quality which is good enough but not too good for the purpose at

hand Purchasing on specification is not particularly popular with vendors who include in their regular selling price the cost of establishing their trademark, but all companies, no matter how small, can use it The only requirements are care in setting the specifications and in inspecting goods upon arrival At times specifications may well be modified to fit the goods available Slight and unimportant modifications of specifications may bring considerable reductions in quoted prices because the revised specifications will fall within the standard output of one or more of the vendors

Sometimes specifications are determined not by the buyer or by the vendor, but by the market This is particularly true with commodities which are subject to wide quotation, such as raw cotton, staple cotton yarns and cloth, and lumber In such cases the purchasing department can only determine the grade to be bought and then see that the commodity as delivered falls within the market regulations for the grade ordered In some organizations the engineering department determines specifications Even in this type of organization the purchasing department has an interest in the specifications and frequently makes suggestions that result in large savings in purchasing It is apparent that under such circumstances the purchasing agent must have a good technical background

Selecting the source of supply In addition to following the normal courtesies in seeing salesmen and in observing the strictest business ethics in matters of awarding bids, the purchasing agent needs to keep accurate records of the performance of suppliers and the quality of their goods In times of material shortages the purchasing agent is under greater pressure to seek out new suppliers and to hold old ones However, the reputation of the firm and the particular purchasing agent has a lot to do with holding old suppliers when materials are hard to get Salesmen trained in their product should have ideas which are valuable to the purchasing agent and to the concern which he represents To win the favor of as many vendors' representatives as possible is to have these men working for the interests of the plant also In this way the purchasing agent should be in constant touch with the newer developments of the trade He can be of invaluable aid to his company, particularly the engineering or design department, not only through his judicious placing of orders but also through his knowledge of trade conditions

Initiating the purchasing requisition For record purposes regular materials used in production are usually under the control of a *balance-in-stores ledger clerk* If minimum ordering points have been determined and maximum ordering quantities fixed, this clerk fills out a requisition when the ordering point is reached This requisition may be sent to the superintendent, general manager, or production-control departments for

approval, or directly to the purchasing department, depending upon the procedure previously determined For maintenance supplies the order may originate with the maintenance department if these materials are not under the control of the balance-in-stores clerk For engineering or technical materials the order usually originates in the engineering department If central purchasing is practiced, these orders are sent to the purchasing department regardless of the person taking the initiative in starting the order

Securing quotations or bids For certain standard items purchased in large quantities or other items purchased according to specifications, it is often advantageous to secure quotations The purchasing department sends to a selected list of suppliers a request for a quotation for the specific articles or materials, giving detailed information or specifications, the quantities desired, the delivery schedule expected, and practically all the other information found on the regular purchase order When the quotations are received and prices compared, the order is usually given to the lowest bidder who can meet the requirements laid down When the purchasing department is functioning properly, the order usually will go to the lowest bidder, since the department will not request a bid from an unreliable supplier

Placing the purchase order The purchase order (Fig 28 3) is usually made out with two or more copies, the exact number depending upon the needs of the organization Some of the uses for various copies are as follows

1 Original or vendor's copy is sent to the vendor

2 A copy is kept in the purchasing department and filed numerically by the order number for ready reference

3 A copy is sent to the receiving department as a notification to be on the lookout for the material

4 A copy is sent to the department initiating the order

5 A copy is sent to the accounting department

6 A copy is sent to the follow-up clerk or division of the purchasing department

7 A copy is sent to the inspection department

Few organizations use all seven copies, but nearly all of them, except the very small ones, use at least two or more, frequently three The purchase order is a very important document and should be so drawn that misunderstandings are not likely to arise It should include the following details in addition to the firm's name and date

1 Purchase order number to be used by the vendor in billing and shipping the material

2 Quantity of material ordered, expressed in terms commonly used for this purpose

MEMBERS
AMERICAN INSTITUTE OF STEEL CONSTRUCTION
AMERICAN STEEL WAREHOUSE ASSN

PURCHASE ORDER

TIPS ENGINE WORKS

P O BOX 896 AUSTIN TEXAS

PURCHASE ORDER NO MM-967

J W Minder Chain & Gear Co
6011 South Central Avenue
Los Angeles 1, California

ORDER DATE November 16,

REQUISITION NO M-192

TO BE SHIPPED VIA J H Rose Truck Line

SHIPPING DATE 3 weeks

CONDITIONS and INSTRUCTIONS

RENDER INVOICE IN DUPLICATE and mail with Original Bill of Lading or Shipping Receipt
ACKNOWLEDGE RECEIPT PROMPTLY—Advise shipping date.
SHOW THIS ORDER NO on all packages and papers
No responsibility will be assumed for verbal orders given employees outside the purchasing department

24 Sprocket Roller Chain 3/4 Pitch Single Width
19 Teeth (Hardened) Type "B" Hub Std 3/8"
Keyway 1 2500"/1 252' Bore one 1/4"-20 Setscrew
Hole over Keyway One 1/4"-20 Setscrew Hole 90 Degrees
from Keyway
Tips No 1CB-30508 Net Ea $5 60

6 Sprocket Roller Chain 3/4 Pitch Single width,
19 teeth (Hardened) Type "B" Hub 1-1/4" Hub Length
2 4390' / 2 4395" Bore No Keyways and No Setscrews
Tips No 1CB-30509 Net Ea 4 67

13 Sprocket Roller Chain 3/4 Pitch Single Width
17 Teeth (Hardened) Type "B" Hub 1-1/4" Hub length
Std 1/4" Keyway 0 938'/0 940" Bore (Std Tolerance)
No Setscrews
Tips No 1CB-30510 Net Ea. 4 35

Prices shown per your quotation No 5496 Terms 2% 10th or 25th
as specified on quotation
For use on Contract No N592-180S-9001

Chg Acct No. 1014-M4

TIPS ENGINE WORKS

By________________
PURCHASING AGENT

Fig 28 3 Purchase order

3 Description of the material ordered in detail so that there can be no chance of error This description should be in terms of standard specifications where possible

4 Delivery date requested

5 Detailed shipping instructions the place to be shipped to, the method of shipment when there is a definite preference, kind of packaging, etc If these items are omitted, the vendor will follow his own interests, which may not be in keeping with the desires of the purchaser

6 Billing instructions

7 Price, when an agreed price has been established
8 Terms, when these have been agreed upon
9 Any other item of importance, such as protection against damages arising from patent infringements

The actual procedure of placing an order is illustrated by Fig 28 4 Other procedures may be used, depending upon the needs of the particular company It is essential that the purchasing agent know the general market level of prices, as well as the prices which he is being asked for

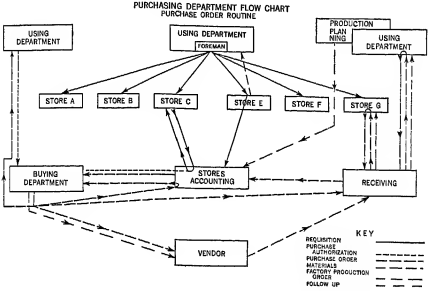


FIG 28 4 Routing a purchase order in a manufacturing company

particular materials This information will enable him to appraise the quotations which he receives He must also have a thorough knowledge of discounts and datings current in the trade at the time Frequently, although reductions from list prices cannot be secured, the same effect may be gained by an increase in the discount for cash Particularly in times of tight money, alert purchasing agents can reduce the cost of purchases materially by this means In order to know when to place orders, the purchasing agent must have a knowledge of general business conditions If he is not to fear quickly rising or quickly falling markets, he must study trade reports and general reports of business conditions, these are readily available Some general managers keep careful watch over the relations of purchasing agents and vendors, for the reason that the purchasing agent represents the company before a large portion of the business world Some

companies will not allow the purchasing department to let contracts to anyone but the lowest bidder without first consulting some designated member of the general management

Follow-up, receiving, and inspection Frequently the purchasing agent follows up his own purchases At other times the follow-up may be done by another person who specializes in this work The actual follow-up may only be a phone call or it may require a visit to the supplier's plant or to a railroad center to break a freight tie-up It is essential that the receiving department notify the purchasing department of the receipt of all purchases, as well as the count and the condition of the material when received If there is a separate inspection section for the receiving department, this division reports on the quality of the goods received and at times on the count Either the receiving or the inspection department must notify the purchasing department regarding the count and the condition of the material received so that the purchasing department can approve the invoice for payment The copy of the purchase order sent to the receiving department may be returned to the purchasing department with the correct count and the condition of material noted on it, or this same information may be given the purchasing department on a special inspection or receiving report

Purchasing records The purchasing agent needs many records in order to buy wisely and to insure the delivery of materials when needed Among many records he needs is a list of manufacturers, dealers, or jobbers who are in a position to supply the articles which are regularly used or who may be considered prospective bidders on any special commodities which may be required from time to time All such information should be complete to be of maximum value It should include the location of the plant and the sales offices, the names of the persons to be dealt with, the freight rates, any necessary remarks concerning the freight situation between the point of shipment and the plant, such as congested junction points which may delay the shipment, and a notation of whether the concern is in a position to fill orders from stock or must manufacture them to order Other items of interest on these firm record cards should be facts regarding the manufacturing capacity or usual supplying capacity of the firm and the maximum size of the orders that they can handle Catalogues may be arranged by cross reference to this list

Purchase records are usually maintained in three ways in most effectively run departments, namely, by firm name, by articles, and by purchase orders The purchase records by firms include a sort of account for each firm with whom business is carried on This record is used to check over receipts and invoices, as well as serving as a record on which to base the issuance of future business In maintaining this record of purchases

by firms it is most essential that all discounts and datings be carefully noted, as these will serve as a check when purchases are next made from the company in question and are quite as important as the quoted sales prices A quotation file will ordinarily be composed of the returned "request for quotations," which have been sent out originally by the purchasing department, and will be valuable in checking over any new quotations which may be received, in settling disputes concerning reasons for granting previous orders to other bidders, and in providing a general bird's-eye view of the policy of the purchasing department with reference to the concerns which are invited to bid This quotation file gives the complete history of all orders on which bids have been requested before the actual filing of any of these orders The actual purchase records may duplicate some of this information, but this duplication will not be harmful, inasmuch as when the information is wanted it will be most easily found as a quotation or as a purchase order, depending on the need at that particular time

Purchase records by articles are useful in showing the trends of prices and in discovering whether bids that are received are high or low, particularly on commodities and articles for which there is usually no stated "market" One error which is frequently encountered in this type of record and which must be guarded against is the placing of dissimilar commodities on the same card because of the incomplete description which is on the card or on the purchase order Purchase records are usually maintained in all purchasing departments by purchase order number, if in no other way All shipments must ordinarily be marked with the purchase order number, and incoming goods are checked against the purchase order by the purchasing department before it approves the invoice and sends it to the accounting department for payment This type of purchase record usually consists of a retained copy of the purchase order, a copy which ordinarily has spaces for office records not appearing on the original of the order that goes to the vendor Such notations include, "approved for payment," "expense distribution," "partial receipt"

The tickler follow-up of orders outstanding consists merely of a file, wherein special copies of the orders or separate slips bearing the order number are placed, to be called to the attention of the designated person at a stated date after the papers are placed in the file By calling orders to the attention of a member of the purchasing staff at certain periods before the material is actually needed in the factory, it is possible to make certain that the material will be on hand when wanted, or at least that extra effort may be made by the purchasing department to secure it by the proper time

29 CONTROL THROUGH THE USE OF THE BUDGET

Background of budgeting Budgeting developed largely in local governmental units Later it was taken up by the states and national government J O McKinsey published his book, *Budgetary Control,* in 1922 This book profoundly influenced the adoption of budgeting as a tool of business Early budgeting applied principally to expense, but it was soon expanded to cover sales, production, plant additions and changes, and revenue The success of the firms which applied it correctly encouraged others to try it, and soon budgeting had undergone an amazing development in business

The nature of the budget The budget arises from a plan, an objective, and a predetermined standard for carrying out the plan in terms of the objective The business budget has been described as

1 A method of rationalization whereby—

Budget

Estimates covering different periods of time are, by the study of statistical records and analytical research of all kinds, established for all and everything affecting the life of a business concern which it is possible to express in figures

Control

These established standards are constantly revised and checked for the periods determined, in the light of actual achievement, with the double purpose of correcting the estimates, and of initiating the investigation and correction of causes of discrepancies [1]

2 An instrument tending to promote cooperation, coordination, and control

3 a particular form in which a sales forecast and plan of management may be expressed that will facilitate their use in management The term *budgetary control* will be used to mean the way in which such a budget is used to organize, coordinate, and stimulate the activities of executives, and to control income and expense [2]

The budgetary concept in business implies the idea of planning, forecasting, and coordinating so that the business will operate as a unified

[1] National Industrial Conference Board, "Budgetary Control in Manufacturing Industry," p 11, quoting from an editorial in the *Bulletin of the International Management Institute,* July, 1930, Geneva

[2] John H Williams, *The Flexible Budget,* McGraw-Hill, New York, 1934, p 4

whole Budgets must be developed not only by means of forecasts of business conditions as they affect the particular enterprise but also on the basis of past history, carefully interpreted The form of a business budget, its complexity or simplicity, is determined largely by its purpose and by the nature and type of the organization using it Unlike budgeting for governmental work, a reduction of expenditures in a business may lower the revenues directly A reduction of an advertising expenditure may decrease the sales and hence the income, and the reduction of a manufacturing expenditure may directly affect production and hence the source from which income is derived

Objectives of the business budget Not only does the budget make possible the development of departmental programs, but it is a means of curtailing overexpenditures in departments Preconsideration of items of expenditure makes possible the recognition of leaks, both at the time the budget is being considered and during the period of its operations When expenditures for plant enlargement are subjected to a careful survey of their purposes and their justification, with a realization of what they will mean in terms of expansion of sales and production, hasty enlargement of plants is often eliminated, and assets retained to carry on activities for which they are already needed Bankers are steadily and increasingly demanding more knowledge of operations and programs They are asking for information concerning not only balance sheets, character, and capacity but also prospective operations In increasing numbers bankers are demanding submission of a budget which will definitely indicate when loans are going to be repaid, with substantiating figures, at the time when the application for a loan is made

Who should be in charge of the budget The general manager or another major executive should be in charge of the budget Regardless of the title of the officer or committee nominally in charge of the budget, the major executive officer is in reality the responsible budget officer Good organization may necessitate the delegation to others of many of the routine phases of budget construction and operation, yet in the final analysis its success or failure rests on the shoulders of the chief executive The actual amount of time that he must give the budget will depend largely upon the efficiency of the operating units and his immediate subordinates This situation illustrates the *exception principle in management* The actual title of the person supervising the details of the budget is frequently the budget director He usually reports to the chief accounting officer, the chief finance officer, or the general manager In case the budget largely covers manufacturing, the budget officer frequently answers to the manager of manufacturing

The initial budget Unless top management is *squarely behind the budget* and is willing to devote the time and direction to give it reasonable likelihood of success it should never be started The National Industrial Conference Board survey listed some eighteen mistakes or misunderstandings that companies have encountered with their budgetary programs [3] The first eight of these mistakes indicate rather specifically conditions that might well have been considered before the original installation, namely

1 Expected too much
2 Installed too rapidly
3 Inadequate supervision and administration
4 Bad organization
5 Inadequate accounting system
6 Inadequate cost system
7 Inadequate statistics of past operations
8 Expected results too soon

Even under favorable conditions the installation of a budget is an educational process It requires time The by-products of budgetary installation are frequently more important than the budget itself Inadequate supervision and administration usually accompany failure by management to recognize the underlying significance of the budget Budgeting cannot be reduced to a formula It requires judgment of the highest order It is better by far not to undertake the budgeting of an enterprise than to doom it to failure from the beginning by bad organization and inadequate supervision The existence of factual data of past experience from which to construct the budget is essential Unless the accounting system is so organized as to make possible the collection of information with which to fix specific responsibility, the budget should not be undertaken If the accounting system is not designed to provide these data, modification of it to make possible the current collection of the required information should precede any effort at budgetary control What has been said regarding accounting is equally applicable to other statistical data that may not come directly under the accounting department It is highly essential that the performance of each budgetary unit be measured in terms of those items for which it can be legitimately held responsible

Constructing the sales budget The sales budget is the foundation upon which all budgeting depends. There are times and situations in which the sales budget is limited by the productive capacity or the financial budget During normal business, however, experience has tended to emphasize the budgeting of sales first and then the construction of all other budgets in terms of anticipated sales On the assumption that the production de-

[3] National Industrial Conference Board, "Budgetary Control in Manufacturing Industry," p 16

partments can turn out all the product that the sales department can sell, there are three primary approaches to the sales budget

1 Each salesman throughout the country estimates the total sales by items that he thinks he reasonably can expect to make during the next budget period These estimates are summarized by territories, and a sum total is drawn up for entire anticipated sales Each salesman's estimate may be increased or decreased by his regional supervisor if the supervisor feels that the particular salesman is either too pessimistic or too optimistic This estimate is a pragmatic one and has the advantage of being in effect a pledge on the part of the men actually in the field to perform

2 The central statistical division, after having studied past performance of sales by items in relation to certain indices, may build up a scheme of forecasting sales either in terms of total volume or, better still, by products By using regional information about the general economic situation, this total estimate may be broken down into estimates for localities Certain industries have been experimenting with this method with considerable success The outstanding problem is to find the proper index, especially one that anticipates performance

3 A third method combines both of the foregoing ones The statistical estimate is modified after being checked by the men in the field This seems to be the most successful method The sales department's estimate includes a full statement not only of necessary expenditures, but also of probable sales and shipments during the budget period, subdivided by kinds and unit value as well as by total value The estimate of shipments is equally as important as that of sales, as upon it will largely depend the time when cash receipts may be expected This estimate must be based on a consideration of past history as well as of the seasonal factors that may be involved, the business and competitive conditions in the industry, the obsolescence or style factors which may be present, the traffic conditions, and the relation to the manufacturing program, both as regards production needs and the extent of unfilled orders An important consideration is the available demand at various selling prices, with the margin of profit that is left under each condition The cost of securing large volume, with full data from the manufacturing departments, will in great measure determine the output that the sales force will attempt to sell

A few of the major considerations in constructing the current budget are

1 The attitude of the management should be fairly clear with respect to the influence of the position in the business cycle It is not possible to know exactly the movement that will take place, however, intelligent budgeting cannot be undertaken without careful consideration of the cyclical trend

2 Modernization of production equipment should be considered, especially when such modernization will directly affect departmental budgets

3 As far as is practicable due consideration should be given to salary and wage changes that may be anticipated during the proposed budgetary period

4 Plans for contraction or expansion of production should be noted During every period some organizations are contracting, whereas others are expanding This situation exists in periods of both depression and prosperity A contracting program requires special care to avoid catastrophe An expanding program also demands watchfulness to take full advantage of the opportunities offered Formal declaration will tend to focus the entire organization's attention on such problems and thus will usually prevent the overlooking of some important item

5 Policy concerning product change, development, or the introduction of new lines should be stated Any major change will frequently make heavy demands on expenditures for equipment, advertising, and sales effort

The budget usually starts with a preliminary conference of the major department heads, in which the trends of the business and of industry in general are considered, and broad lines of progress are mapped out with the aid of the general manager and others who formulate the basic policies If the controlling factor is the amount of goods that can be sold at a profit the first budget that must be constructed is the sales budget The departmental heads then prepare budget estimates based on the general program that has been outlined These budget estimates are usually submitted to the budget officer Although the details of the budget may be delegated to a lesser official, in reality the chief executive is the budget director, and the responsibility is his even though details may be handled by his representatives The budget officer strives to harmonize the respective estimates of the various departments He may call a meeting of two departments whose activities are closely related to harmonize apparent differences When all parties have been heard the budget officer constructs his budget This may be submitted to all interested parties at a group meeting before it is finally delivered to top management for approval When finally determined, the budget should be prepared in a satisfactory form and distributed to all interested persons in order that they may know definitely what is expected of them If a budget is actually to control, rather than to be a hoped-for but impossible ideal, it must be flexible and elastic to meet variable conditions that may occur during the budget period There are always some aspects of the future that cannot be forecast These unpredictable factors include minor changes in general business conditions, although major swings of the pendulum should be visualized, such as changes in consumer demand Changes in consumer demand may be basic, as a change in the type of material in fabrics, or they may merely involve style, such as changes in the patterns, colors, or weights of a fabric Modifications in sales and production schedules may have to be made on account of the unparalleled favor that is suddenly afforded one particular product

The manufacturing budget The objective of the manufacturing budget is to establish standards for manufacturing operations as interpreted in costs and to provide the manufacturing division current reports to see how closely performance conforms to expected standards If standard articles are being manufactured, the number in each unit of time during the budget period may properly form the basis of the manufacturing budget, with all expenditures dependent on this budget If, however, the concern works to the customer's order or is largely influenced in the exact amounts of

different lines or styles that it manufactures by the day-to-day demands of the market, it is probable that the manufacturing schedule must be worked out in terms of units of material or of cost The manufacturing budget must be determined not alone from the estimated sales but also from the requirements of the manufacturing departments An attempt must be made to run the plant on as even a keel as possible the year round, and the manufacturing budget, as well as the sales department's estimates and the financial requirements of the plant, must be developed with this purpose in mind The unit costs of manufacture under varying amounts of production need to be closely studied by the manufacturing executives in order that they may intelligently make recommendations concerning the spread of the manufacturing program over the course of the budget period Efficient budgeting of production calls for a series of budgets at various productive levels The manufacturing budget is a *step budget* rather than a single budget for a given quantity This aspect of budgetary control is possibly its greatest contribution to efficient management It forces the persons responsible for decisions to think through the problem before it arises and thus insures prompt action when the budget is used effectively The estimated payroll can be determined on the basis of prospective production by carefully analyzing past payrolls at various levels of production, and from these figures making allowances based on changes in wage rates or in productive effectiveness A consideration of additional payroll costs due to overtime work or to the necessity of adding to the overhead will often serve as a means of stopping sales-expansion programs which otherwise appear desirable

The manufacturing budget may lead to a consideration of each of the following

1 Attempts to stabilize production through building up a finished-stock inventory during slack periods

2 Development of supplementary products which will make possible a balanced production fully utilizing equipment

3 Consideration of the desirability of manufacturing or purchasing component parts and facilities for storing materials

4 A consideration of production costs of varying outputs

Budgeting the service departments The budgets of the various plant service departments, such as traffic, shipping, and stores, may be included in the general manufacturing budget, or they may be developed separately, inasmuch as, like other service functions of the factory, the amounts of outlay for them are more or less constant, regardless of the manufacturing program The budgets of the general business service departments, such as the general office and the personnel department, should be capable of close estimate and easy preparation by the heads of these departments

Although certain phases of maintenance and other services are relatively constant, others are closely related to the productive hours worked. The roof will need repairs and the buildings will need paint even though production approaches zero, however, the maintenance of machinery, sweeping of floors, and many other items can be made to parallel the productive output.

The financial budget The financial budget cannot be prepared until the other major departmental budgets are fairly near completion, since it is directly dependent upon them. The foregoing statement is true where the company is in a sound financial position and has ample credit facilities. There are situations in which the financial position may dictate all other budgetary programs. For example, it may be desirable to increase the inventory of finished goods, but this cannot be done unless funds are available to carry the additional inventory. Of course, the expected volume of sales, anticipated collections and profits, and all expenses must be considered in building the financial budget. The financial budget should include a statement of the probable cash income and expenditures by months and a careful analysis of the times at which the company will be compelled to borrow in order to carry on its manufacturing program, as well as the times at which it may be expected that the loans will begin to be repaid and the times at which they may be completely repaid. From the other budgets, cash outlays must be determined through a consideration of such separate items as materials, direct labor, overhead expenditures, administrative and selling expenses, state and federal taxes, fixed charges, and improvements to the plant. From the close analysis of all these items prospective balance sheets for various times during the budget period may possibly be constructed.

The length of the budgetary period Some automobile manufacturers have a master budget covering the anticipated operations for the ensuing year's model. This master budget is broken down into a quarterly or a 3-months' operating budget, which is the basis for some of the major purchases. The quarterly budget is broken down into a detailed operating budget of 1 month or, during slack periods, to 10-day releases and is revised at the end of each month in the light of current performance. Such a budget is in reality a step budget that is carefully controlled in keeping with current performance. In different businesses the variations in the length of turnover of money and the importance of the seasonal factor will partially determine the length of the budget period. It should always be long enough to cover at least one complete cycle of operations, provided seasonal features and manufacturing to stock in anticipation of later sales are important in the business. General business conditions will influence

the length of time that the budget estimates should cover and the number of revisions that must be made

Summary Budgeting cannot take the place of adequate executive control of operations, it is only an aid in performing this function The effectiveness of the budget is directly dependent on the effectiveness of administration within the several departments It is an influence which should lead to better executive control but can never replace it The actual construction and operation of the budget facilitates coordination and control Each participant in the budgetary process is enabled to see how his department fits into the enterprise as a whole, as well as the many factors comprising his own department The budget tends to secure the following actions or results, which are achieved either as a part of constructing the budget or in striving to meet the goal it establishes

1 Builds morale when operated in a truly managerial spirit (It is highly important that the budget should not become a clerical instrument operated by an individual with only a clerical outlook)
2 Facilitates financial control
3 Analyzes all the factors affecting the departments and the business as a whole
4 Harmonizes departmental programs
5 Designates departmental and individual responsibilities and authority
6 Provides management with a guide to daily activities and a means of control
7 Serves as a medium of disseminating policies throughout the enterprise
8 Serves as a restraint upon unwise expenditures
9 Harmonizes sales and production programs
10 Provides a strong incentive for the achievement of the established goal
11 Provides a basis for measuring performance
12 Tends to aid in stabilizing production

30 OPERATING THE BUDGET

The budget in operation To be effective the budget must remain dynamic It can retain its dynamic features only when the general manager gives it his support and personally uses it in his contacts with his division heads Reports form the basis of the general manager's control of expenditures during a budget period He should have information available at all times regarding the percentages by which each department is above or below its quota If the operation of the budget is to be effective, he should question constantly with *wisdom* and *understanding* the figures that are appreciably out of line Department managers must maintain similar checks on operations and expenditures within their departments If department budgets are used effectively, there will be but little need for action on the part of the general manager or his budget officer Alternate budgets may be prepared to be used when changed operating conditions require it Such flexible budgets may be prepared departmentally, and without further instruction, if departmental activities vary by certain percentages, the departments know the percentage by which they should increase or decrease their expenditures If the costs of basic materials or of direct labor vary by specified percentages, definite predetermined authority may likewise be given the production departments to increase or decrease their expenditures in definitely stated proportions, and similar authority may be given the sales department to vary its estimated receipts from sales It is at times more practical, however, to call for revisions of the budgets when basic conditions change

General budgetary control The original construction of the budget should provide the necessary tools for control The basis for operating control through the budget is laid in the original construction of the budget itself *Adequate accounting procedure must be provided to supply current data relative to the performance of each budgeted unit* The organization must have been developed to the point that a specific person is charged with the responsibility for the performance of each departmental or divisional budget Otherwise it will be better to postpone any attempt at budgeting, for confusion and overlapping of responsibilities are certain to arise *Estimated costs of operating the major divisions must have been set up in*

keeping with expected sales volumes Table 30 1 shows an annual budget for a machinery manufacturer This master budget is broken down further into a monthly budget It is desirable that top management receive a monthly report comparing the performance for the preceding month with the budgeted operations This same monthly report should include a comparison of performance to date with the actual performance for the corresponding month of the previous year

Table 30 1. Estimated Annual Sales and Cost of Goods Sold by the Charleston Machinery Company

(Hypothetical Figures, 000 Omitted)

	Estimated Annual Sales	Cost of Goods Sold	Percentage Cost of Goods Sold	Direct Labor	Percentage of Direct Labor in Cost of Goods Sold	Direct Material	Percentage of Direct Material in Cost of Goods Sold	Burden (180% of Direct Labor)
Products								
Electric hoists								
Machines	$ 2 000	$1 140	57	$228	20	$ 502	44	410
Parts	1 100	605	55	103	17	317	52	185
Resale	900	540	60			540	100	
Total	4 000	2 285	57	331		1 359		595
Electric drills								
Machines	1 400	700	50	119	17	367	52	211
Parts	700	364	52	58	16	202	55	104
Resale	400	260	65			260	100	
Total	2 500	1 324	53	177		829		318
Air drills								
Machines	1 400	742	53	104	14	451	61	187
Parts	1 200	576	48	75	13	366	64	135
Resale	900	612	68			612	100	
Total	3,500	1 930	55	179		1 429		322
Total for all products	$10 000	$5 539	55	$687	12	$3 617	65	1 235

The difference between profit and loss is frequently dependent upon the accuracy and comprehensiveness of budgetary control As the budget period progresses, the general manager must have accurate reports of operating conditions within the business It is on the basis of these reports that changes in the budget will be made Periodic reports, monthly or semimonthly, will inform him of the profits and sources of profits within the last period These reports will be compared with past periods and with the budget Such reports will include a statement of earnings, operating expenses, and profits for the month, as well as an income statement, which will be divided into budget accounts Major expense headings will be given for each department comparing expenditures with the budget

As a part of general budgetary control the checking of current business conditions against expected conditions is essential Various economic

services are available to assist in forecasting business conditions In addition to the commercial services, some of the more important sources of information are the statistical data of the Federal Reserve Banks, the reports of the Bureau of Labor Statistics and the Department of Commerce, the forecasts of the several university bureaus of business research, and independent statistical studies of business cycles In the light of developments as the budgetary period progresses the budget may need revision

The departmental budget Each department head not only must be familiar with the details of his budget but also must impart this information to his assistants so that the *team* can achieve its objective with *confidence* and *understanding* The accounting department should set up a budget-accounting procedure which will provide an account for each budget allotment and then post expenditures under that allotment to that account Each of these accounts should be checked regularly and the department notified when the allotment seems to be in danger of being overdrawn Department heads should examine such sheets or summaries of them at frequent intervals, and check them against the departmental budget This checking is for the purpose of aiding in positive control All too often budgetary operative controls are reduced to negative checks which tend to break down morale and bring the entire movement into disrepute When properly operated, these controls provide a goal to reach and stimulate morale One of the most effective means of getting all the supervisors behind a budget is to have some form of supervisory bonus to be paid for meeting or approaching the budgetary standard

Action on new programs should not be taken by any department unless it is assured that the budget will not be endangered Of course, if a new program is necessitated by a situation arising after the construction of the budget, adjustments will have to be made to meet the requirements of the new situation The budget must never become a restraint upon progress or scientific management but must remain a tool of efficient management Construction and other activities in which it is difficult to predetermine costs with accuracy must be checked more closely than normal manufacturing operations

Operating the sales budget Table 30 2 illustrates the type of information that should be provided the sales manager and other major executives The sales manager is also interested in similar reports for the various regions and individual salesmen and in the sales by products If sales in a given territory are falling, the sales manager tries to determine the cause and may send special assistants to the region to aid If the failure is caused by a drought or another natural reason, analysis may show that some other region is profiting through the misfortune of the drought area Additional sales effort in the fortunate area may well absorb in part the

unavoidable loss in the drought region Some budget officers, in addition to rendering special monthly reports similar to the one in Table 30 2, express the same data graphically Graphic presentation is especially helpful in portraying trends (see Fig 30 1)

Table 30 2 Sales Department Budget for October

(26 Working Days)

Income and Expense Accounts	Budget Estimate	Actual Figures	Variation	% of Variation
Sales at list price	300,000	318,000	18,000	+ 6 00
Total sales to date	3,600,000	4,032,000	432,000	+12 00
Salaries, executive & clerical	6,300	5,958	−315	− 5 00
Salaries, salesmen	6,000	6,000	0	0 00
Commissions	5,700	5,358	−342	− 6 00
Travel	1 050	1,155	+105	+10 00
Advertising	9,375	9,375	0	0 00
Other expenses	1,200	1,140	− 60	− 5 00
Trade discounts	10,200	10,506	+306	+ 3 00
Department expense for month	39,825	39,519	−306	− 0 77
Nine preceding months	443,550	441,051	2,499	− 0 56
Ten months to date	483,375	480,570	2,805	− 0 58

The labor budget Departmental executives must distribute the budgeted payroll in such a way that total labor costs for the department will be within budget estimates, and at the same time wages must be changed to conform to daily requirements The department head must have his estimated payroll and his actual payroll constantly before him for comparison Increases in salary must be given at the proper time to salaried employees When employees resign and are replaced by others who do not receive the same rate, the budget is influenced Incentive wage systems facilitate the predetermination of wage costs, and yet exact wages cannot accurately be predetermined A variation of a few cents on the jobs of a number of workers for a number of days will make a great difference in labor costs over a budget period The personnel department must secure the labor budgets for the several operating departments and make arrangements to have the necessary number and type of personnel available at such times as the prospective manufacturing schedule indicates is necessary Sufficient personnel must be hired to provide for the high mortality rate that occurs, even under the best conditions, immediately after hiring The training budget for new employees is very difficult to establish and follow The availability of jobs on the outside frequently determines the labor turnover

The research and development budget It is extremely difficult to predict the cost of a research project as well as the results to be attained The executive in charge of development and research is required in his

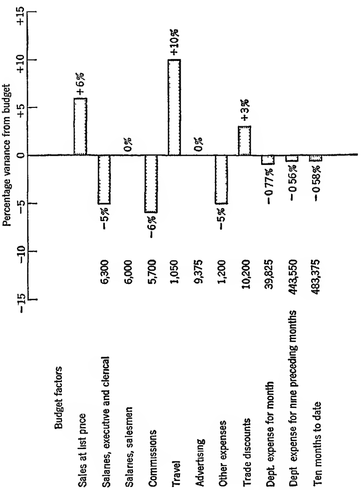


FIG 30 1 Chart showing percentage variations from budget Data from Table 30 2

original request to set forth in as much detail as possible what he hopes to accomplish, how long he estimates it will take him to achieve his goal, how much money he estimates will be required, and what results are expected if his endeavors prove successful All expenditures on a given project are charged against it The executive in charge is notified monthly regarding the budget standing of his research In turn, the director of research at stated intervals reports his progress to his superiors,

including both the time element and the degree of success to date When it becomes evident, as it often does, that the original allocation of funds will not be adequate to pursue the project to a successful conclusion, the director of research should notify the budget officer and his immediate superiors He should report progress to date and file a new request for funds to complete the project if he thinks that such expenditures are justified The budget committee and the management then have to decide whether finances permit further expenditure at the time, whether other researches should be deferred, or just what should be done with the available funds

31 MANAGERIAL CONTROL THROUGH COSTS

The Nature and Use of Costs

The place of the cost department in the organization The cost-accounting department may be found under the accounting department, under the industrial engineering or standards department, under the production-control division, or under the plant superintendent, general manager, or some other important official A consideration of the personalities involved or the capacities of the regular accounting division may be the determining factor in locating this important section of a business At the time when cost accounting was established as a separate function, there may have been good reason for placing the cost work somewhere other than under the regular accounting division Tradition and the momentum of an early start may preserve this separation long after the original cause has been removed On the other hand, good cost accounting requires a thorough, although not necessarily a technical, knowledge of production processes, which often is lacking in the regular accounting section This is frequently the determining factor in locating the cost-accounting department Cost accounting provides information on which management decisions may be based Like other business methods, it is not an end in itself It is of value only in so far as it aids in making intelligent executive decisions that promote the healthy advancement of the business Cost reports, regardless of their value, are inanimate and cannot themselves make improvements or insure intelligent action They must be studied by the executives and translated into the operations Cost reports give the information for control, but the executives do the controlling Cost reports must be current if they are to provide a basis for managerial decisions Since many students of industrial management have not had the advantage of a formal course in cost accounting, a few elementary concepts will be presented in this chapter [1]

[1] It is highly recommended that all young men entering business study accounting, at least through introductory cost accounting The fact that many of our successful managers today have not had such courses is no argument to the contrary These successful men have acquired the fundamentals of accounting the long, hard way Experience is a good teacher, but often an expensive one

Classification of costs *Factory expense* is composed of all those burden items which are capable of being allocated to the factory, such as waste, depreciation, repairs, taxes, insurance, indirect labor, power, heat, light, and salaries of factory supervisors and clerical workers *General expense* includes general administration and managerial costs, such as main office salaries and expenses, legal costs, the portion of power, heat, light, and depreciation expenses which is chargeable to the central office group, accounting, and other items, such as communication expense, general office supplies, and sometimes institutional advertising, public relations expenses, and similar items *Selling expense* includes those items that are directly

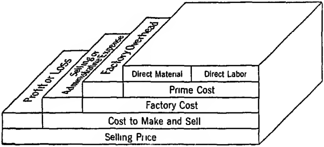


FIG 31 1 The cost steps

chargeable to selling The exact breakdown of this expense, like all the others, may vary with the individual concern and the use made of the costs Advertising, for instance, is frequently chargeable with little difficulty to sales, yet some institutions classify this item under general expense (see Fig 31 1)

From the standpoint of the operating factory executive the classification of costs as given below is helpful

1 Prime costs = direct material costs + direct labor costs
2 Factory costs = prime cost + factory expense
3 Cost to make and sell = factory cost + selling expense
4 Total cost = cost to make and sell + general administrative expense
5 Selling price = total cost ± profit or loss

The elements of cost Costs are usually made up of the money expended on materials, labor, and expense *Direct materials* are those that go into the product and can be directly traced to it *Indirect materials* are those that are necessary in the production process but are not directly used in the product itself, such as coal, oil, and sandpaper Other materials that go into the products but are difficult to trace to a given product are often for practical reasons classed as indirect material, such as nails,

glue, putty, and sometimes paint The same material may be a direct material for one producer and an indirect material for another Labor is also classified into two groups, direct or productive and indirect or nonproductive labor [2] *Direct labor* can be allocated to a specific product or products, whereas *indirect labor* cannot readily be thus assigned The method of wage payment may influence the classification of labor as direct or indirect A janitor is ordinarily paid on a day-rate basis, and his work is usually classified as indirect In some departments the entire group, including the janitor, may be paid on a group piece-rate basis In this case the janitor service is directly allocable to the product and therefore is classified as direct labor Depreciation, interest, rent, taxes, heat, light, power, and similar items are just as much a matter of cost as materials and labor These cost items are commonly called *overhead expense or burden* *Fixed expenses* are those costs that tend to remain relatively constant regardless of the volume of production, such as the interest on bonds, taxes on land, buildings, and equipment, depreciation arising from the passage of time, and rent *Variable expenses* are those items that tend to vary directly with the volume of production, such as depreciation arising from use, royalties paid on a volume basis, power, and salaries of minor clerks and some subforemen

In a strict economic sense there may legitimately be some argument about classifying rent, taxes, and interest as expense items From the managerial point of view these expenditures are a charge against the business enterprise and as such must be paid out of revenue or out of capital if the revenue is not large enough to cover all outlays Regarded in this light, they are in a very real sense expenses

Against what products shall factory expenses be charged? For conveniences the output of a factory may be classified into the following groups

1 The primary product
2 The by-products
3 The joint products
4 Waste

The *primary product* may be readily recognized as the main product which the enterprise is designed to produce, such as steel in the steel mill and fabric in the textile mill A *by-product* is a product resulting from the manufacture of a primary product It may have considerable value, but

[2] "Productive' and "nonproductive" in a sense are inaccurate when applied to labor, although they are in common use All labor should be productive or else abolished The mere fact that labor may not be directly traceable to a given product does not mean it is nonproductive in the strict sense of the term

its production is incidental to that of the major product Cotton seed is a by-product of the "ginning" of cotton In the past, by-products have often been ignored Even today items that might well be marketed as by-products are often ignored unless the total volume is large For instance, small packinghouses frequently do not have the full line of by-products that large packers have When each of two products resulting from the same production process has considerable value, they are known as *joint products* Common illustrations are butter and buttermilk, meat and hides, coke and artificial gas The relative values of two joint products are usually more nearly the same than those of a by-product and its primary or major product *Waste* may arise from the manufacture of a major product, joint products, or a by-product Waste has relatively little value and sometimes may constitute an expense, in that money must be spent to get rid of it

All costs that can be allocated to the primary product are thus allocated All costs incurred in processing the by-product after it is separated from the major product are chargeable to the by-product If the competitive market for the major product is keen, the sales price of the by-product minus all costs allocable to it is frequently subtracted in figuring the cost of the major product In an effort to find true costs this practice may be followed anyway, but it is almost certain to be done where margins are low and competition is keen In the manufacture of joint products all costs incurred after the two products are separated are usually allocated to the respective products The costs of the joint products up to the point of separation are often divided between the two on the basis of the total sales value of each The cost of saving the waste is naturally charged to the waste The recovery value is usually so low that no special effort is made to figure it into the cost of the product from which it is derived The distribution of factory expense is complicated even for a major product and becomes increasingly so for by-products and joint products Absolute accuracy is not possible, but accuracy for managerial control is attainable To illustrate some of the methods used and some of the difficulties involved, a few of the bases for distributing factory expense are presented

Distributing expense against direct labor Burden or expense can be allocated according to (1) *the actual number of direct labor hours worked* or (2) *the cost of the direct labor hours worked* These two methods give the same result when the men are paid at the same rate on a time basis Such a condition seldom prevails, hence the two systems are usually different The distribution of expense on the basis of direct man hours worked on a given product is predicated on the assumption that these expenses are proportional to the man hours worked The system is simple, and its simplicity may account for its wide use When the rates paid the workers are relatively the same and the amount and the nature of the work vary

only slightly, this system is accurate for most purposes It has the advantage of emphasizing the time element in the distribution of indirect costs, however, it emphasizes only "worked" time and does not consider "elapsed" time, which is also an important item in costs This system does not distinguish between the different kinds of equipment that may be used in processing work possessing different characteristics It is self-evident that a carpenter working with hand tools is not in fact carrying so much burden as a man working on a large boring mill in the same department

The direct labor-cost basis of distributing expense is predicated on the assumption that burden is proportional to the direct labor cost This system ignores the effect of elapsed time and does not emphasize the time worked quite so definitely as the direct labor-hour basis The other advantages and disadvantages of the direct labor-cost basis are essentially the same as those of the direct labor-hour basis, but the direct labor-cost basis has an additional advantage in that the data are accumulated for other purposes and need not be specially segregated in the same sense that labor hours have to be collected Where the rates vary materially in the department, the results of the two systems will be different

Application of expense according to the material used The distribution of expense on the basis of direct material is predicated on the theory that indirect costs vary in direct proportion to the direct material used This system is logical for continuous-process manufacture of a standardized product If more than one line is turning out products that are materially different or if the same line turns out different products this system tends to be less applicable It is of doubtful value for burden distribution for an industry producing a variety of products

Application of expense on the basis of prime costs Burden distribution on the basis of prime costs is in reality a combination of the systems which have been described and possesses both the advantages and the disadvantages of each This system has not met with widespread acceptance

The machine hour used as a basis of applying expense The machine-rate basis of expense distribution in its more highly developed form strives to allocate to each machine its true expense when considering all costs, such as original cost of machine and expected life, power consumption, heat, light, floor space occupied, and maintenance By carefully estimating the expected use of a machine and dividing all costs allocable to this machine for a given period by the total number of expected use hours, the burden charge per hour can readily be obtained By keeping a record of the time a machine is used in manufacturing a given product, the burden cost of each machine can be charged to the product This method involves considerable record keeping, but it is theoretically preferable to many of the other systems Failure to use the machine the anticipated number

of hours leaves a portion of the burden undistributed, whereas usage of the machine for longer than the estimated time distributes burden greater than is factually justified Again, if a machine larger than necessary is used for a given job because machines of the proper size are overloaded or broken down, the particular product thus processed will be charged more than it should ordinarily be It is true that these shortages or excess charges may be accumulated over a period and adjustments made, but it is not so easy to make these adjustments for an individual product in a jobbing shop Individual costs including either excesses or shortages in burden distribution are particularly undesirable when they are used later for estimating purposes

The production-center basis of applying expense A given production center may or may not be separated by aisles or partitions Each center does, however, have definite boundaries and may well be thought of as a special room All the charges for this particular center, such as floor space, repairs, heat, light, power, and maintenance, can be allocated to the center as a unit These total charges are then distributed on a time basis over the total product moving through the center The production-center method of expense distribution is a logical expansion of the distribution by machine-hour method and eliminates most of the objections of the machine method This system is theoretically sound, but it requires a great deal of careful work to establish correct rates for each center The same problem of overcharges and undercharges arises as in the machine-rate basis in cases where the center has less or more production than was anticipated for the given period Excess charges because of using a larger machine than necessary are less likely to occur under the production-center method of expense distribution than under the machine basis because the production center usually has both machines

Combining various methods of applying burden[8] Two or more systems may logically be used within an organization when they best serve the requirements of the enterprise In one department practically all the production may be machine work, and the basis of burden distribution may well be the machine-hour method or the production-center method In another department of the same enterprise most of the work may be hand assembly, either on benches or on an assembly line In this department the direct man-hour or direct labor-cost basis may well be the best one to use In a department where there is a large amount of both machine work and hand work, it may be advisable to apply machine burden, such as power, depreciation of machinery and equipment, repairs and maintenance of machines, and insurance and taxes on the machines, by the machine-

[8] See Charles F Schlatter, *Cost Accounting*, John Wiley & Sons, New York, 1947, p 500

hour method, and at the same time distribute burden arising from supervision, welfare expense, heat, light, and other items that apply more intimately to the workers than to machines on the direct labor-cost basis

Depreciation

Definition *Depreciation* is defined as *the reduction in the value, or the effective economic life, of a product arising from the passage of time, use or abuse, wear and tear, influence of the elements, or the cessation of demand for use* [4] Depreciation frequently is used to include obsolescence and inadequacy or supercession The mere passage of time creates physical decay or decrepitude in such things as buildings, boilers, rubber products, and other productive instruments Repairs will prolong the life of such items, but eventually they must be replaced Wear and tear take place with use and are relatively proportional to use, however, the time element may influence the rapidity of wear When a factor in production is being consumed in production, regardless of the cause, the value of that portion of the factor consumed is a cost of production Fixed assets are constantly being converted into expense which must in the long run be recovered in selling price in order that the buildings and equipment may be repaired during their effective lives and replaced when they are no longer economically usable [5] The expense arising from the conversion of fixed assets into the product sold may take several forms, such as wear and tear and physical decay resulting from the passage of time, obsolescence, and inadequacy Inadequacy in and of itself may not in a strict sense be an expense, but it certainly lessens the value of the item to a going concern and thus gives rise to excess expense if the equipment is forced to do work for which it is not large or powerful enough Again, inadequacy may compel the purchase of additional equipment, an expenditure which would not be necessary if the equipment were adequate

Obsolescence *Obsolescence* refers to the process of equipment's becoming out of date The equipment may still have useful productive life for the specific operation for which it was originally purchased, but this operation may no longer be economical because of the development of newer types of equipment, new processes, or new inventions Obsolete equipment has little or no value save for scrap, whereas inadequate equipment may have much valuable productive life remaining Equipment inadequate in one situation may be entirely satisfactory in another where there is less work to be done Obsolescence is more common in newer

[4] See L P Alford, *Cost and Production Handbook,* Ronald Press, New York, 1937, pp 1215–1221

[5] Land is an exception to this statement

industries in which development of processes and product is more rapid A basic discovery in any industry, however, may render much of the equipment obsolete Model changes in the product may render certain tools and dies for the old model obsolete, not because they are replaced by a newer tool for the old product, but because the product has changed, so that new tools and dies are required This situation is common in the automobile-body industry Systematic provision for the obsolescence of equipment is difficult, save in those industries in which models change at regular intervals, the special equipment is then frequently written off in a short time Frequently no attempt is made to segregate obsolescence as such, it is included in depreciation by making provision to retire the equipment in a shorter period than would be justified by wear and tear arising from use or the passage of time

Depletion Some business assets, such as coal or iron deposits, timber, and clay deposits, are consumed in being prepared for market Minerals, when removed from the earth, are not replaceable Provision may be made to replace trees, but such replacement takes a long time Earnings from operations such as mining represent two items (1) profits from operations, and (2) recovery of part of the capital investment Reduction of the mineral deposit through removal for use is known as depletion It may be legitimate to distribute to the owners the total income from such operations, but they should be clearly earmarked to avoid confusing a return of capital with earned income Patent [6] rights and franchise privileges lose their value with the passage of time, and provision should be made to amortize their value during their effective lives, there will be a partial depletion of capital if the total income is distributed Provision for depletion may be made through investing the accumulated funds in similar or other assets, instead a special sinking fund may be established by investing these funds in income-bearing securities and reinvesting the income, so that the total amount will be available at the expiration of the effective life of the item

Basis of depreciation The three common bases of depreciation are (1) original cost, (2) replacement cost, and (3) present value or appraised cost Depreciation on the basis of original cost, which includes transportation and installation costs, is simple and easily determined by referring to the equipment ledger Depreciation on this basis will tend to retain the original investment intact Some authorities argue that the objective should not be merely to preserve the original investment but to preserve the organization as a going concern, and that this purpose will not be ac-

[6] A patent grants its owner the exclusive right to manufacture for 17 years, a copyright is effective for 28 years and may be renewed for another 28

complished by merely recovering original costs during a period of rising prices, hence they advocate depreciating the asset on the basis of its replacement cost There is considerable merit to their argument, but its practical application involves a great deal of accounting and revision of depreciation charges as price levels fluctuate This basis has merit when appraising an enterprise for financing and insurance purposes, but it has little standing with the income-tax collector and may be criticized on the basis that costs as far as possible should reflect actual, rather than estimated, expenditures The present-value basis or the fair market-value basis has had particular standing in certain special cases involving property acquired before March 1, 1913, and property acquired by gift or transfer in trust after December 31, 1930 In industry in general, however, it has relatively little significance

Methods of computing depreciation The *straight-line method* of computing depreciation is by far the most common one in use The machine-hour method is another method that has merit but has found little use in industry Both the percentage on diminishing value method and the sinking-fund method of computing depreciation have theoretical interest but have had practically no use in industry The *straight-line* method of depreciation assumes that the depreciation takes place in equal increments throughout the life of the equipment The life expectancy of the machine is estimated, together with its scrap value From the cost of the machine is subtracted the scrap value, and the remainder is distributed equally among the estimated years of life of the machine For instance, a machine costing \$2000 and having an estimated life of 10 years and scrap value at the end of this period of \$200 would have an annual depreciation of \$180, computed as follows (\$2000 − \$200)/10 = \$180 This method gives a constant depreciation rate for each year which in reality does not conform to actual depreciation, since a machine depreciates more during the first few years of its life than during the last years Maintenance costs are greater during the later years of the life of a machine, and these, when added to the straight-line depreciation charge, will give an unequal charge against production If it is desirable to have a relatively constant machine cost chargeable to production, the straight-line method is not satisfactory

The machine-hour method of figuring *depreciation* is founded on the theory that depreciation is proportional to use The estimated number of hours the machine may be used before replacement is taken as the base, and this figure is divided into the amount to be depreciated to get the machine-hour rate of depreciation This amount is then charged as a depreciation expense for each hour's use of the machine The system has much to commend it but has not received wide acceptance in practice

Using Cost Data

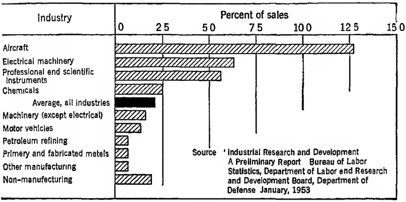
Use of cost information To be effective in control, costs must be charged in such a manner as to coincide with areas of responsibility It is a waste of time for control purposes to send a foreman a report showing an increase in the cost of production arising from conditions over which he has no control The responsible executive should be charged only with those costs over which he exercises reasonable control The foregoing statement raises the question of the disposition of the excess unit burden costs arising from a decrease in the volume of production It is self-evident that the enterprise as a whole must bear all costs whether or not they are currently recovered in the selling price of the product, however, it does not follow that each individual department must be charged for control purposes with all costs If the department is not charged with all the expense, how should the undistributed burden be handled? One method is to establish a burden charge for each department for an expected normal volume and to use this charge as a basis even though production may fall below this norm [7] The excess burden would then be applied directly to profit and loss as a charge against management rather than against the individual department This or a similar program is incorporated in standard costs, which will be discussed later

In periods of depression when the payroll must be cut at all hazards and regardless of ultimate cost, departmental analysis of costs which indicate savings effected under different operating conditions, as well as actual expenditures, makes possible intelligent pruning of the payroll, rather than using the hit-or-miss methods which are inevitable if analyzed data are not available The cost-accounting department should be in a position to furnish valuable statistical information, or, if there is a separate statistical department, to give this department the basic data from which the statistical information may be gathered The personnel department should be able to gain accurate information concerning the actual cost of replacement of workers Such information can be secured most logically from the cost records Although the data may be taken off the production records by the planning department before they are turned over to the cost department for costing, nevertheless this is primarily a cost problem Such studies are only samples of the way in which cost information may be utilized

If new functional departments are constructed or if development programs are undertaken, the cost system should allow computation of the

[7] In substance this was the method advocated by H L Gantt in his article in the *Journal of the American Society of Mechanical Engineers*, Aug , 1915

savings effected through the changes (see Fig 31 2) If job-study work is developed, it is most desirable to be able to balance the cost of taking the studies against the savings achieved through lower unit costs on the operations studied If a planning department is instituted, it should be possible to know the savings in direct and indirect labor in the factory departments which have resulted from the expenditures incident to the creation of the



Source 'Industrial Research and Development A Preliminary Report' Bureau of Labor Statistics Department of Labor and Research and Development Board Department of Defense January, 1953

FIG 31 2 Cost of research as a per cent of sales by industry, 1951

planning force Such information becomes of particular value when extension of planning work is contemplated, since it answers opposition successfully when the planning department has proved its value, but it prevents hasty extension when conditions demand a higher degree of success with work already undertaken, rather than the assumption of new work

Current costs influence price largely through serving as a signal to indicate whether operations are profitable at a given price For a time it may be better business to continue to sell at a price which does not recover all burden costs rather than not to sell at all In the short run competition may be the determining factor in price Even in the long run competition may set the upper limit of price, but the long-run lower limit of price under competitive conditions tends to be determined by the cost of production of the representative firm in placing the goods on the market In other words, costs determine the survival of a company rather than the price of its goods, since price is determined by competition in a free market

Standard costs In standard-cost systems the normal expenditure for material, direct labor, and overhead charges for a given product or for a number of hours' production in a given department is computed This

allows the elimination of much detailed cost analysis and at the same time permits adjustment at the end of a period through the totaling of actual departmental cost during the period and comparison with the normal or standard cost. If the actual cost of a given job performed during the period is wanted, the figure may be secured through applying the ratio for the period between the standard and the actual cost of all jobs to the particular job in question. Such a system is valuable because it permits the formulation of long-run production and sales policies which are not disturbed by minor fluctuations in operating conditions, and furthermore it makes possible the separation of normal production costs from costs which are due to the position in the business cycle or to general efficiency or inefficiency in the management as a whole.

If an attempt is made to secure an absolutely accurate cost on each order, a cost that will currently absorb all overhead or indirect charges, a fluctuating cost necessarily results, making difficult the determination of long-run business policies. Under many cost systems in which overhead costs are largely prorated as business is carried on, these costs have not been added in sufficient quantity when business was good, thus cutting down selling prices and prohibiting the establishment of a reserve for bad times. Similarly, they have been added too heavily in times of slight production, with the result that costs have increased as selling has become more difficult. Frequently, managers have realized the impracticability of spreading overhead over a greatly diminished product and have charged a large share of it directly to the profit and loss account. They have less commonly kept their overhead up during times of prosperity, so as to create for themselves a reserve to which they might charge the unabsorbed overhead in times of depression.

The cost of idle equipment. Management is keenly aware of the need for keeping plant and equipment busy so far as possible. If the costs from not using equipment are directly listed under some such heading as idleness expense, they will force themselves to the attention of the chief executives for correction, and selling prices can be fixed to include some of this cost of idleness or to exclude it entirely, as may be deemed wise under the prevailing conditions. This policy will be determined largely by considering whether the product can be sold in competition if the expense is added. The planning department not only is able to furnish the cost department with information concerning idle equipment but also is in a position accurately to determine the cause of idleness. It remains for the cost department merely to compute the cost of idleness and to submit reports to the executives responsible. These executives may then take the necessary remedial action in an attempt to reduce or eliminate the existing idleness. Of course, the necessary information concerning causes of idleness can be

secured without reference to the cost department, but the inclusion of cost figures not only gives the information attention value but also permits comparison with the cost of taking steps to remedy the conditions causing the idleness

Fixed and variable costs Direct wages, direct labor, and certain types of indirect expenses, such as the salaries of minor executives, who may be dropped in times of poor business, and income taxes, which vary almost directly with business done, are variable costs Fixed costs remain constant, almost irrespective of the amount of business done These costs include not only the salaries of major executives, but also interest on investment, particularly borrowed money, taxes on property, and certain obsolescence charges on both materials and equipment Cost reports should clearly differentiate between these fixed and variable costs Although the rendering of idleness-expense reports will partially cover this field, nevertheless both the cost department and the interested executives should bear in mind constantly the distinction between variable and fixed costs All reports that clearly separate them will be of major assistance in the control of costs and in formulation of sales and production policies and of administrative budgets Variable costs are all "out of pocket" costs, hence they must be recovered first, what is left contributes to the recovery of "fixed costs," after which profits are earned

On the assumption that a given company has a fixed expense of $2000 per week, produces a product the variable cost of which is $60, and produces and sells 50 of these units per week, it would just recover both fixed and variable costs by its operation when it sold $5000 weekly With these figures it is apparent that the variable costs are 60 per cent of the sales price and 40 per cent of the sales price are applicable to fixed costs and profit (if there be any) In case the same company's sales were $7500 for a week the variable costs would be 60 per cent of $7500 or $4500 The $4500 variable costs + the $2000 fixed costs = $6500 total costs When the $6500 total cost is subtracted from $7500 total income from sales there remains $1000 profit

Fixed costs do not remain exactly fixed as given in the simple illustration above and variable costs may not remain the same per unit of product As production increases, the variable labor costs per unit are likely to decrease somewhat Possibly some other variable costs also decrease slightly Some variable labor costs may increase slightly under some conditions, such as when production requirements call for overtime and time and one-half pay for overtime In some cases these variable costs of different types will have to be segregated in the cost reports Tables can be prepared which will indicate the variable cost per unit at different points in the production scale, as well as modifications in fixed cost which are

likely to occur as production changes With these data the general management will be in a position to determine general sales and production policies, although the information thus obtained will not be exact enough for the accurate fixing of selling prices Thus a consideration of fixed and variable cost is useful mainly as a guidepost for the formulation of major business policies

Budgeting and the system of costs The cost records of past years give dependable information, but the current cost figures must be utilized in laying out the budget for the months to come During a budget period cost records can be carefully analyzed in the light of the budget, which was prepared as a goal The cost record becomes the progress report on obligations fulfilled by department heads and permits modification of operating procedures or change of business plans during the course of a budget period This fact indicates the necessity for developing cost records in accordance with the organization of the business Standard costs are a valuable aid in budgeting, although it is possible to use the budget without standard costs [8] Although no particular phase of sound management will alone insure successful operation, all operating decisions must in the end be based on costs Thus costs become the basis on which management policies and decisions are determined Costs must not only be accumulated accurately but also in a manner which permits their utilization for the formulation of management policies and the execution of management programs

[8] See Paul E Holden, Lounsbury S Fish, and Hubert L Smith, *Top-Management Organization and Control*, McGraw-Hill, New York, 1951, pp 152–161

32 CLASSIFICATION AND IDENTIFICATION

The need for classification Classification, under modern business conditions, is a necessity The merits and results of classification should not be confused with the advantages of the various systems of symbolization which make the classification usable in the day-by-day operations of the business A classification is a detailed, systematically arranged list of all items pertaining to a particular phase of a business or to all the various phases of a business Classification *facilitates interpretation* and *ease of reference* of seemingly unrelated facts Not only are known data rendered usable by classification, but also unknown relationships have been hypothecated in terms of logical interpolation of the known ones Satisfactory wage rates for new operations have frequently been established by reference to classifications of similar work New jobs have been evaluated in terms of established classifications The following tabulation lists classification as the second step in scientific methodology

1 Observe accurately all the facts involved
2 Classify and combine all the facts on the basis of some common relationship or relationships
3 Interpret the relationships in terms of a law or statement explaining the observed relationships
4 Test the formulated statement or law and note any deviations

Without adequate classification there are likely to be duplication and overlapping in the collection of such data Classification within a business makes possible the establishment of a system that makes record collection routine

The advantages of classification development are as follows

1 It provides a logical system for the filing of all data
2 It establishes a method for obtaining the information necessary for the operation and control of an effective accounting system, facilitates the collection of data pertaining to indirect expenses and manufacturing costs, and aids the establishment of monthly inventory balances of stores, materials in process, worked-material stores, and finished products
3 It aids materially in showing tendencies, thus a comparison of performance over a period of time for any operation or activity shows the direction in which this

item is moving A comparison of classified expense items invites managerial approval or action

4 It clearly indicates the plan of organization, in that it shows the relationship of divisions and departments and interprets the limitations of their activities

5 It aids the development of standardization The word is here used in the special sense of the determination of the best method or the best material to use for any given purpose under existing conditions, and strict adherence to the best as a standard until a better standard is found In almost every instance in which classification is applied, it will be found that a large number of almost similar articles are being used for similar purposes In order to reduce the amount of classification work, if for no other reason there will be a tendency to reduce the number of items This reduction helps to create standards When a particular item is ascertained to be the best, it is adopted, classified, and recorded

6 It aids in standardizing the arrangement of articles in storerooms and prevents the incorrect issuing of articles such as often happens when names or shop terms are used on the requisition

7 It furnishes a means for routing and controlling material in process by accurately designating the materials, machines work places, and operations entering into each process or component part

8 It makes possible the collection of detailed information relative to buildings and equipment

The basis of classification Both the specific use to be made of the classification and the length of time it is expected to be used influence the base to be selected If the classification is to be used as a part of a continuing program a base should be selected that provides for expansion The common bases of classification are

1 Classification by the *nature of the materials* themselves, such as liquids, solids, gases, acids bases, salts, metals, woods, ceramics

2 Classification by the *use to which they are put* or the *purpose served,* such as direct materials and indirect materials, mechanical rubber goods and automobile tires, tubes, and flaps

3 Classification according to the *location of the plant* or *department where the material is used* This method may be in use if two or more plants in the same area are under the same general management but are operated as separate units

Classification by the *nature of the material* is capable of indefinite expansion into a logical system Such a system may be complicated for a relatively small plant, but in large, complex institutions it is often a necessity Classification on the *basis of the use* to which materials may be put is simpler for smaller organizations, and to the mind of the average workman this system has a strong appeal It seems logical to him to associate the material with its use As far as the worker is concerned, *classification by location* is similar in many ways to classification by use From a control angle, labor may be classified as *direct* or *indirect* In terms of the employment office, labor may be grouped as *unskilled, semiskilled,* or *skilled* Regardless of the given base used for classifying any material,

product, service, or persons, attention should be devoted to whether the basis selected is *adequate* and whether it is *capable of expansion to meet changing conditions*

Developing the classification Every element of the business, taking into consideration all existing departments, all materials in stores and in process, all finished products, all work places and machines, all operations performed, all fixtures and tools, all buildings, and all possible sources of expense, must be listed with infinite detail After the preliminary data have been collected, the subjects to be classified are divided and grouped into a number of main classes, each of which is designated by either a number or a letter, depending on the method used Each main group is then subdivided or further described to the extent that is necessary After each group and subgroup have been formed and carefully revised, the attaching of symbols to each item may be begun Care should be taken not to subdivide the main groups any more than is actually necessary, otherwise the symbols will be long and unwieldy On the other hand, simplification of the classification should not be carried to such an extent that confusion or misunderstanding will result No more features of the business should be classified and symbolized than will actually be utilized when the standard nomenclature has been built up The cost of classification is heavy, although the return on the investment is large Certain fundamental features can be used in almost every classification, but there are others in which nicety of judgment must be exercised before deciding whether to incorporate them For instance, almost every plant has need for some control over its raw materials or parts in process in the storeroom To secure this control, it is necessary to establish a method of requisition withdrawal from the storeroom As soon as this method is introduced, standard nomenclature generally becomes a very useful mechanism, both for the location of the article itself in the storeroom and for the abbreviation and simplification of the clerical work attached to the writing of requisitions

In almost any of the continuous or analytical industries which handle a single material from start to finish, an elaborate classification for routing, including identification of all materials in process, finished product, machines, and work places, might be expensive, burdensome, and unworkable On the other hand, an involved assembly industry is lost without a good routing classification In recent years, considerable attention has been given to job classification [1] and some attention to the personnel

[1] See American Management Association, *Personnel Series*, No 39, pp 17–22, Industrial Management Society, *Occupational Rating Plan for Hourly and Salaried Occupations*, 1937, also Scott, Clothier, and Spriegel, *Personnel Management*, McGraw-Hill, New York, 1954, Chaps 10 & 11

audit, which is based upon careful classification of all jobs or occupations A classification is useful only to the extent to which it is kept up-to-date An accurate record of all persons holding copies of the classification should be kept, so that, when changes are made in the original classification, arrangements can be made to have additions and changes entered on all copies This problem can best be handled by the standards, methods, or research department, or, in some institutions, the production-control division has charge of this function

Identification The simplest form of identification, which is the use of the regular name for the article or service identified, may be satisfactory in a small institution having only a few items, however it is extremely burdensome, wasteful, and subject to error when applied on a large scale Identification is accomplished also by the use of signs or symbols, numbers, letters, or a combination of these with words In actual usage these name substitutes become quite as well known as the name itself Probably the best-known use of symbols is the chemical formula Plants, buildings, production centers, machines, trucks, products, many parts, forms, and various accounts are often assigned an identification other than their common names Such a procedure promotes *precision* and *accuracy* and materially reduces the chance for error once the identification symbols or numbers have been firmly established The use of appropriate identification numbers greatly reduces the amount of clerical writing necessary in connection with records of parts, materials, and operations It is customary in production control to refer to the operations in sequence, as well as to the machines upon which the various operations are performed, by appropriate identification numbers The use of numbers to identify labor operations and materials facilitates machine tabulation of cost data

Standardizing the system of identification for use of all departments The ideal would be to have the same identification system used throughout the company This is possible if the respective heads of all interested departments collaborate in setting up the system Tabulating equipment requires that numbers be used for identification On installing such a system, it is highly desirable to standardize the system of identification throughout the company if possible In some companies one system is used by the sales department, another by the product-design or the engineering department for blueprints, a third by the production-control and the manufacturing division, and still a fourth by the accounting department Such a program entails a great amount of editing when orders are received and costs are accumulated At times there may be good reason to use one set of identifications for sales when these numbers have become well established in the trade

Systems of identification. The most widely used systems of identification are:

1. *Alphabetical:* the use of a letter or a group of letters according to some predetermined scheme.
2. *Mnemonic:* the use of letters in some such combination that they suggest the classification name of the particular item. Numbers may be combined with letters in the mnemonic system, particularly to suggest size or some generally accepted standard.
3. *Numerical:* the use of numbers to identify the particular item.
4. *Sign:* the use of symbols or signs to indicate items or operations. These have been extensively used in motion study techniques.
5. *Combination:* the use of any of the foregoing systems in combination with any other one or all others to identify a particular item, service, or operation.

The mnemonic system (originated by Frederick W. Taylor and his associates) may be expanded to classify and symbolize every phase and item of a business. Another advantage of the mnemonic system, as its name suggests, is that it aids the memory by suggesting the classification name. To illustrate, ML signifies *mill,* GR, *grind,* AM, *material accounts,* and DP, *punch-press department.* *Letters* have been used extensively to identify buildings and departments. It is but a simple step to progress from single letters to combinations. Many of these were worked out before the introduction of the logical mnemonic system. For instance, department A in building B may be known as BA, the building being always written first. If there is more than one similar department in a building, numbers may be added to indicate the different departments, thus in a rubber plant BA may stand for a pressroom in which miscellaneous sizes of tires are cured, and BA1 may indicate a pressroom in which only 1 size of tire is run, such as those tires used on the Ford or Chevrolet. Drawings, parts, and cost classifications may also be designated by letters. Unless a logical system is worked out, letters become unwieldy in a large institution having many items to be classified.

In general three systems utilize numbers for identification: the use of consecutive numbers, the assignment of particular groups of numbers to certain well-established classifications, and the Dewey decimal system. The use of consecutive numbers is simple and may be satisfactory in a limited way for such items as general notices to the plant. When the number of items is great, consecutive numbers are not satisfactory unless accompanied by a cross-indexing system for ease of reference. The assignment of certain groups of numbers to established classifications is a well-known system and, when scientifically worked out, is capable of indefinite expansion and is entirely satisfactory. This system is widely used

in accounting A simple allocation of numbers might well be as follows

1	Departments	1–199
2	Asset Accounts	200–299
3	Liability Accounts	300–399
4	Revenue Accounts	400–499
5	Expense Accounts	500–

A logical system can be built up by a proper combination of numbers that soon becomes generally known throughout the organization Certain positions indicate specific classes or groups For instance, the first 2 numbers usually indicate the class of machine and the last 2 the machine number within the class as follows 0501—automatic-feed turret lathe, 1, 0502—automatic-feed turret lathe, 2, etc Every phase of the enterprise can be readily classified by proper analysis and thought The Dewey decimal system is best known in library science It has been used in industry but has few if any advantages over the use of assigned numbers to certain classifications and has the disadvantage of increased possibility of error through misplacing the decimal point This error may be obviated by omitting the decimal point and indicating its position by the use of zeros thus 015 is used instead of 015 However, in such numbers as 00019 it is very easy to omit one of the zeros

33 INVENTORY CONTROL

Definitions Material that has not undergone any major change since its receipt is usually classified as *raw material* *Material in process* is material that has been processed in part but as yet is not ready to be shipped to the consumer Material in process may be in any stage of completion, from the material issued by the stores department but as yet having no operation performed upon it to finished material still held in the production unit ready to be turned over to the stockroom or not yet reported to the control division as ready for shipment *Finished products* have been completed and are ready to be shipped to the consumer Where there is a separate stockroom or shipping department, the product is considered a finished product when it is turned over to this unit *Supplies* are all the materials that are used as aids to production but are not part of the product itself Such items as oil, sandpaper, and polishing compound come under this heading Sometimes small tools such as knives and hacksaw blades may be classified under the general heading of supplies

The need for inventory control Inventory control is essential to effective production or financial control [1] The stores and partly finished stock on hand often represent from a quarter to a half of the capitalized value of the business Poor control of materials is frequently accompanied by poor storeroom administration in a way that may easily throw out of balance any operation programs which have been adopted If the business is budgeted, or if only sales and production programs are adopted, it is essential that an inventory control be set up which will provide material as it is needed without tying up large sums of capital which might be used in operating the program No system of budgeting can be successful unless effective inventory control has preceded it Otherwise production obligations cannot be met by the manufacturing department, at least within the allowed cost The daily routine of cost accounting, with or without an administrative budget, demands that material be controlled accurately and intelligently

The losses due to excess purchases provide a continual argument for small stocks, and the losses due to production tie-ups furnish a strong motive for large stocks It is between these two conflicting forces that a

balance must be struck Proper inventory control will reduce costs arising from any of the foregoing causes Losses from improper control of inventories include purchases in excess of needs, the costs of slowed up production resulting from material not being available when wanted, and losses through improper diversion of material, either wastefully or willfully

Stealing, although important, is usually the smallest source of loss from improper material control In some plants workmen have uncontrolled access to the storeroom This freedom sometimes results in startling losses, especially of materials that are easily disposed of to pawnshops or junk dealers or that can be used in the workers' homes Improper diversion of material may be reduced or eliminated by proper inventory control The storeroom is a service department, and prompt delivery of materials to the manufacturing floor is all-important To promote smooth factory operation and to prevent piling up of idle machine time, proper material must be on hand when it is wanted If material is not available in continuous-process industries, temporary shut-down of a large portion of the plant may result In plants in which operations, machines, and orders have been finely balanced, these shut-downs cause great loss Frequently material is thrown away, lost, or damaged while in process, without any records providing a check One cause of this condition is the plant's allowing excess material to remain in the production department to be used on future orders, rather than having it returned to the storeroom This practice is common in assembly plants, where cartons of raw material, the product of other plants, are used extensively In such shops issuances are not closely checked in the storeroom or elsewhere against production orders, and thus standards of consumption are for the most part lacking In other shops, if the workman damages material, he can usually receive an additional supply from the storeroom with little questioning

Essential steps in inventory control are

1 Fixing minimum quantities, or ordering points, and maximum quantities, or amounts to order, on all materials

2 Arranging a method for allocation of material to orders which are in process or are contemplated

3 Creating stores accounts, which will control the storeroom and not be controlled by it

Maximum and minimum quantities The *ordering point* is sufficiently above the minimum inventory to allow for issuing the production or purchase order and for fabricating or processing in the plant, or, if purchased, for delivery by a vendor For control purposes the ordering point is more important than the minimum inventory The *maximum inventory* is approximately the sum of the ordering quantity and the minimum inventory

It will exactly equal these two quantities if the ordered material is delivered just when the minimum inventory is reached Such precision seldom is realized in practice, and as a result the maximum inventory is nearly always somewhat higher than the theoretical figure The same is true of the minimum inventory Under actual operating conditions the inventory may fall below the minimum This is a danger point and is a signal for a close follow-up to avoid a tie-up in production When there are large numbers of articles, it will be well to divide them into broad classes, in all of which the individual articles will have maximum and minimum quantities controlled by the same factors The factors which determine the maximum and minimum point for each article of stores may be divided into two broad groups The first group applying to all articles carried includes general business conditions and the prospects of the particular business Second is a group of factors directly dependent on the article itself These are somewhat intertwined with the first group but may cause special treatment for some particular material

In periods of increasing production and great market demand, ordering quantities may be increased, and the minimum frequently must be raised If business conditions are the reverse, the minimum generally must be lowered A major factor to be considered at the same time is the probable trend of prices in the commodities to be purchased This trend may or may not follow general market conditions Two more general factors peculiar to the business are the condition of its finances and available capital and the extent of storage facilities which are available In considering this second factor, the cost of new storage facilities, or interest thereon, must be balanced against the cost of carrying inventories which the present storage facilities can handle Changes in the line of product, particularly standardization programs in process of development, may easily be the most important of these factors which are general to all materials carried In setting maximum, minimum, and ordering quantities each item should be considered separately in terms of the following factors

1 The consumption of that article over a past period must be evaluated in connection with the general factors just mentioned

2 There is a profitable manufacturing or ordering quantity The ordering quantity, particularly on special goods, indicates the profitable manufacturing quantity in the vendors' plants These quantities can best be determined by experience and quotations Ordering quantities must always be set with due regard to commercial usages

3 Probable depreciation or obsolescence will influence the amount that should be carried in stock

4 On small, inexpensive items the clerical cost of ordering, receiving, and payment of bills may cause an increase in the ordering quantity

5 The time necessary to secure the article after requisitioning must be considered

The first step in inventory control has been taken when the ordering point and ordering quantity have been set. On standard products, made to a manufacturing schedule, these may often be set in a much simpler way by establishing production requirements for a given length of time as the ordering point, and production requirements for another stipulated time as the ordering quantity. On purchased goods for which there is a regular source of supply, the time required will include the period after the shipping date, as promised by the vendor, during which the article is being transported to the user's plant. On worked materials, it will be dependent on the time taken to work up a manufacturing order for the ordering quantity within the plant itself. The work situation in the plant will greatly influence the time required for the plant to produce a given part or assembly.

Economic lot sizes. The desired goal in producing or purchasing an item is the lowest unit cost. This lowest unit cost must consider all costs in connection with purchasing, storing, handling, money tied up in inventory, and waste. In case of producing the item the purchasing costs, such as issuing orders, follow-up, and special freight considerations, are not involved, instead there are the costs of issuing production orders and setup costs. The economic lot size is the one in which the total costs for purchasing or for the total preparation in case of production equal the total average inventory carrying charge. The carrying charge for inventory in a manufacturing industry is substantial, approximating 2 per cent per month.[1] The formula frequently used for computing the economic lot size is

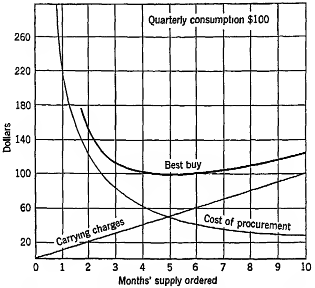
$$Q = \sqrt{\frac{2PR}{CI}}$$

in which Q = economical lot quantity in units
P = preparation costs in dollars, consisting of the clerical cost of preparing the order as well as setup and dismantling costs
R = requirements in units on an annual basis
C = cost of part in dollars per unit
I = carrying charge in percentage per year

Data regarding the economical lot size for a given concern are frequently expressed in the form of a chart from which the desired lot size can readily be taken. The preparation costs are made up of two parts, namely, (1) the ordering cost, which includes all planning and clerical costs, and (2)

[1] See *Factory Management and Maintenance*, Vol. III, No. 8, Aug., 1953, p. 99, H. F. Dickie, "Six Steps in Better Management", Vol. III, No. 3, March, 1953, p. 145, Robert Galloway, "Faster Way to Figure Economic Lot Sizes", and Vol. II, No. 6, June, 1953, p. 123, Siegfried Langner, "Economic Lot Sizes."

the machine setup cost The requirements in units on an annual basis are usually taken from the master budget or master schedule This figure can be only an estimate The carrying charge I expressed as a percentage of the cost of the economical lot includes such items as interest on the investment in inventory, taxes, stockroom expense—storage, etc , depreciation, and obsolescence This carrying charge is frequently as high as 20



Courtesy "Factory Management and Maintenance" August, 1953, p 98

FIG 33 1 Chart showing best quantity to buy

per cent or higher Figure 33 1 illustrates the decreasing cost of preparation with increase in the size of the lot, as well as the increasing carrying cost of the increased lot The economical lot-size formula is not of universal application but must be derived from the facts in a given situation The use of the economic lot is of value primarily when ordering for stock and not in continuous manufacturing

The balance-of-stores sheet There are many different forms of balance-of-stores sheets, ranging from the 2 columns showing receipts and disbursements to the 6-column type illustrated by Fig 33 2 Some of them show vendors' names, purchase order numbers on order receipts, balance on hand, issued, apportioned, available, scrapped, and other data deemed desirable In Fig 33 2 the apportioned column insures that steps have been taken to have the material available when wanted for manufacture and successfully eliminates the practice of relying on the same lot of ma-

KIND OF UNIT Foot	DESCRIPTION 2" Hollow Steel Tubing, "B"	MINIMUM 800 / QUANTITY TO ORDER 4000	SYMBOL SST2B
BALANCE OF STORES			

1 ORDERED BAL.			2 RECEIVED			3 BALANCE ON HAND			4 ISSUED				5 APPORTIONED BAL.			6 AVAILABLE BAL.		
DATE	ORDER NUMBER	QUANTITY	DATE	QUANTITY	VALUE	QUANTITY 6/14	VALUE	UNIT VALUE	DATE	ORDER NUMBER	QUANTITY	VALUE	DATE	ORDER NUMBER	QUANTITY	DATE	QUANTITY	REMARKS
						1500		35								6/14	1500	
						900			6/18	3726	600	21000					900	
						600			7/10	3914	300	10500					600	
7/11	1487	4000														7/11	4600	
													7/20	3982	1200		3400	
						300			7/28	3982	300	10500		"	900			
		0000	7/30	4000	16000	4300		40										
						3700			8/8	"	600	24000			300			
													8/20	4071	2100	8/20	1600	#4071=1800
						3400			8/22	"	300	12000		3982	1800			
						2200			8/27	4124	1200	48000					400	
8/28	1516	4000														8/28	4400	
						1600			9/11	4071	600	24000			1200			
		0000	9/14	4000	15200	5600	21600	39										

FIG 33 2 Balance-of-stores sheet

terial to fill two orders The available column indicates the amount of material which is still available for assigning to orders The last balance in this column, rather than the balance in the on-hand column, is continuously compared with the stated minimum to determine when to order If this were not done, goods well above the minimum might be on hand but might be ordered into production immediately for orders already in the plant to such an extent that the danger point might be reached and passed long before a new supply of goods could be secured This balance sheet provides a continuous check of its own accuracy, inasmuch as column 1 (balance ordered) plus column 3 (balance on hand) should always equal column 5 (balance apportioned) plus column 6 (balance available) after any transaction has been entered

The following illustration shows how the 6-column balance-of-stores sheet is used The article, 2-inch hollow steel tubing, quality specification "*B*," has had its minimum set at 800 feet, and the ordering quantity at 4000 feet The maximum is therefore 4800 feet On June 14, when this sheet was opened, there was on hand a balance of 1500 feet, which was also available to be apportioned The unit value of this material, as brought forward to this sheet, was 35 cents per foot The first transaction was an issue to the shop of 600 feet The next transaction was a similar issue of 300 feet, which brought the balance available below the minimum, and hence an order for 4000, the ordering quantity, was entered Upon ordering, this amount is considered immediately available for apportionment, although it is not yet in the plant, and hence not ready for issue (On commodities or in times when prompt delivery cannot be expected, it is unwise to consider material which has been ordered as available until it has been shipped) On July 20, production order No 3982 was entered, calling for 1200 feet of this article, which was immediately apportioned, and taken from the available column, although the order was not yet placed in production On July 28, 300 feet of this amount was issued to the shop for production, and therefore deducted both from the balance on hand and the balance apportioned On July 30, the material on order arrived, and was deducted from the balance on order and added to the balance on hand The new material cost 40 cents per foot, and there was so little of the old supply on hand that the unit value of all the material was entered as 40 cents The next transaction called for the issue of 600 more feet of the material apportioned to production order No 3982, which was deducted from the balance on hand and the balance apportioned August 20, production order No 4071 was received, requiring the apportionment of 2100 feet, and the balance available for apportionment 1600 feet August 22 the remaining 300 feet apportioned to order No 3982 was issued to production, reducing the balance on hand and the balance

apportioned On August 27 an unexpected order (No 4124) was received, calling for immediate production of articles requiring 1200 feet of tubing This order was placed in production without delay, the full requirements being issued to the shop on the same day that the order was received This again brought the balance available below the minimum, and an order was placed the next day for 4000 feet, despite the fact that there still remained in the storeroom 2200 feet, 1800 feet of which, however, was apportioned to order No 3982 September 11, 600 feet was issued to the shop for order No 4071, thereby reducing the balance-on-hand and balance-apportioned columns September 14, the 4000 feet on order arrived, at a unit price of 38 cents per foot, thus increasing the balance on hand to 5600, while the balance available for apportionment remained at 4400 The total value of the 5600 feet on hand was then $2160 This series of transactions shows how intelligent control of inventories is possible, allowing in advance for all production needs without unnecessarily tying up capital in material on hand It will be noted that, after each transaction, column 1 plus column 3 equaled column 5 plus column 6

The balance-of-stores sheets may be kept in the general accounting office, in the storeroom, or in some portion of the production office, preferably the planning department The most logical place to operate it is a planning department, however it may be kept in various other places

Visual controls Various mechanical devices are used to aid in controlling inventories Many of these are extensions or modifications of the Gantt chart Some companies use various visible index cards filed in the traditional index file or in some instances in a roller type of file It would be difficult to claim which type is best Each fits a peculiar need and serves that special situation During the past 5 years a few companies have begun using the electronic computing machines with the so-called "mechanical brains" for inventory controls[2] It is highly probable that large companies will use these modern electronic devices more extensively as time progresses They are great labor savers and provide needed information in an unbelievably short time

Control of supplies The value of the inventory tied up in supplies may be a small percentage of the total inventory but this does not mean that it can be ignored The same care should be exercised in disbursing supplies as in issuing regular production materials This is true particularly of such items as sandpaper, knives, and others that can readily find their way into workers' lunchboxes Frequently there are special storerooms for maintenance supplies as well as for office supplies Both of these

[2] See *Factory Management and Maintenance,* Oct, 1953, Vol III, No 10, page 138, "Electronic Tally Provides Pushbutton Inventory Control"

storerooms may not have sufficient calls to require a full-time storeroom man A very important function of the storekeeper is the preparation of a periodic summarized report of slow-moving or obsolete materials This report may well be sent to all persons who may aid in disposing of this material Frequently slight adjustments may make possible the using of obsolete material or the temporary substitution of a slow-moving item for a regular one A close control over repair materials serves as a real aid to the purchasing department and frequently prevents overordering Again, such a control helps to eliminate expensive delay by insuring that certain items regularly called for will be available

Taking inventory The shutting down of the plant or store and the taking of a complete physical inventory is still popular with many companies This practice is still used by some companies that also use other methods of checking inventories between periods of total inventory counting The disadvantages of the total physical inventory may be summarized as follows

1 It is taken only once or twice a year because of the cost and inconvenience involved

2 It is usually necessary to shut down the productive processes of the plant for the period during which the inventory is being taken

3 Accuracy is usually impossible Speed is generally the paramount consideration, and no matter how highly organized the inventorying force, there are usually a number of omissions and duplications

A book inventory is never 100 per cent correct, and it is frequently far from this ideal, because of both clerical errors and unavoidable discrepancies between issues and issue tickets Even when a perpetual inventory is provided, the taking of physical inventory cannot usually be completely dispensed with Neither banks nor the Internal Revenue Bureau will accept unchecked book inventories In order to meet this situation some physical check of the book inventory is provided Such a check does not involve closing the plant to take inventory but may be performed in one of the following ways One method is to check material as it reaches the minimum which has been set The taking of physical inventory at the low limit requires little time and work If there are bin tags, it can be done by the storekeeper on his own initiative as he notices that the balance on the tag has reached the minimum If there are no bin tags, the balance-of-stores clerk can make up a daily list of articles which his records indicate have reached the minimum, and this list can be made the basis for checking Special provision may be made for checking items which have not reached their low limit during a period

Another method of inventory keeping is the book record or running inventory, as illustrated by Fig 33 2 This method provides a running

inventory record of every article which is kept in the storeroom Its advantages are the following (1) the total inventory is found simply by taking off a trial balance of the stores ledger, (2) a record of the issuances of materials is afforded, and this may be followed up to see that the materials were actually used for the purposes for which they were withdrawn from the storeroom

The progressive count method of inventory checking is still a third method used Checkers start at one part of the storeroom and make the round of the department, checking all the items in a certain number of bins each day, and comparing them with the balance shown on the bin tag and in the stores ledger In the larger companies one or two men, or as many as may be required by the particular business, may be engaged continuously in counting materials on hand In a smaller plant the services of a clerk in his spare time each day may suffice In either event, at given intervals of a few months all the material is checked

Effectiveness of inventory controls There frequently will be a temptation to depart from the procedure which has been set up because of a rush of incoming material or because of a sudden need for certain material in the shop The slight time momentarily saved in deviating from the standardized procedure will be more than nullified by the complications and losses which will ensue A well-ordered storeroom and system of storeroom operation can be thrown into utter confusion by 2 days' use of lax methods No method as yet devised will automatically increase a minimum on a rising market or decrease it on a falling market Methods provide a useful tool for the management and are a means to an end Together with the balance-of-stores sheet, they form a very satisfactory basis for inventory control No method of inventory control can be substituted for managerial judgment In fact managerial discretion of a high order is required in selecting the particular method of inventory control to be used as well as in actually carrying out this control

34 STOREROOM OPERATION

The location of the storeroom and storage space The ideal location for storerooms and storage space is one that minimizes total handling costs and other costs related to its operation, and at the same time provides the needed protection for the material The location of the storage space will depend on the nature and value of the materials to be stored and the rapidity with which amounts will be received and issued, as well as upon the point at which they will be placed in manufacture Material such as paper pulp is too bulky and used too rapidly to be stored in bins However, the storage problems connected with such materials can well be studied For instance, paper pulp, instead of being stored in huge piles involving rehandling when needed, can be placed on platforms to be picked up by transfer trucks, each platform containing a standard quantity properly tagged to indicate lot numbers and specifications Heavy materials generally must be stored on the ground floor, whereas light materials can be easily handled and can be fitted into almost any location that is otherwise desirable When castings have to be aged, outside storage is both advantageous and economical Materials that are easily broken require facilities for protection, and this protection must take precedence in fixing the storage place Some articles can be stored only under particular temperature conditions, and the storage place must be determined with temperature regulation in mind Inflammable material often demands a separate storage space that not only will protect the material itself but also will reduce the fire hazard for the remainder of the establishment Any plan for the location of a storeroom must be flexible enough to allow for growth and other changed conditions arising over a period of years

Storage must be provided for

1 Raw materials, properly termed "stores"

2 Supplies—materials used indirectly in production, such as oil, expendible tools and auxiliary items, nails, and glue

3 Partly finished materials, or stores on which some work has been performed These are usually termed "worked materials" and may include finished components awaiting assembly or shipment to customers as replacements Purchased components also fall in this general category These may include any item made in the factory, as well as screw-machine products and similar items

4 Finished products awaiting shipment, properly termed "stock" The term "stockroom" is often used to refer to the place where finished goods awaiting shipment are stored

Layout of the storeroom For smooth storeroom operation it is necessary that a section adjoining the entrance to the storeroom be reserved for the receipt of material as well as for its inspection before storage Also, space must be provided for material withdrawn for issue to the production floors but not yet removed from the storeroom Such space will enable the man in charge of the storeroom to work up his issuances in advance, in order that there may be no delay when the goods are actually required Too much space will add to the indirect cost of storing the material Insufficient area will increase costs because of congestion Lack of space in the storeroom will often lead to a reduction of the quantities that may be carried, so that production is seriously hampered

For bulk storage the storage areas and aisle spaces may be marked on the floor with paint The layout of aisles will vary according to the needs of each storeroom, but in general it may be said that main aisles should allow the passage of two trucks and should vary from 6 to 8 or more feet in width, whereas other aisles will usually have to allow for only one truck In blind aisles running up to a wall, allowance may have to be made for the turning of the truck Where the articles stored are generally carried by storesmen, the width of the aisles between the racks has been standardized at 30 inches in some storerooms Figure 34 1 indicates the proper relationship of aisles to storeroom layout

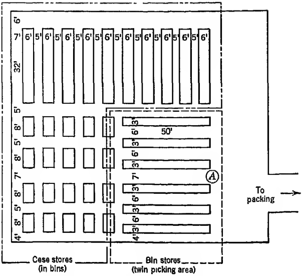
A storeroom having its material properly arranged by classification and marked is not dependent on one man's recollection of where he has placed certain material (Fig 34 2) The plant would not be greatly handicapped even if the whole storeroom force were to leave suddenly Arrangement by classification can be utilized, however, only where there is no rapid change in goods handled Under any circumstances it has certain very definite disadvantages

1 A large amount of space (20 to 25 per cent) must be left in each portion of the rack to allow for expansion

2 The goods most frequently issued cannot be placed near the issue window without breaking down the scheme of arrangement

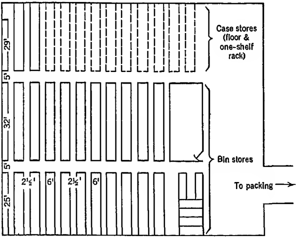
3 Certain goods, such as unwieldy materials or very heavy articles, can under no circumstances be stored exactly by symbol

A second method of arranging the storeroom is to arrange the materials in the manner most convenient for storage and issue, and then construct an *index of location* of the material In the index the material is arranged by symbol, and the location in the storeroom noted next to the symbol



New layout

Open-end, wider aisles, "twin-picking' bin areas, and more cast storage edd up to faster order picking Cut average processing time for orders in half And there s 50% more item storage space in the same floor area



Old layout

Dead-end bins meant a lot of back-tracking for order pickers Most of space was devoted to bin stores–slower to pick than case stores Required twice as many workers Took up large area needed for parts

Courtesy, 'Factory Management and Maintenance No 1953 p 138 and Leslie A Seversen

Fig 34 1 Old and new layout at Central Cientific, Westinghouse Division

This method necessitates designating the racks, rows, and sections in some manner that will allow the bin location to be expressed in the form of a symbol also The racks may be lettered, and the rows in the rack num-

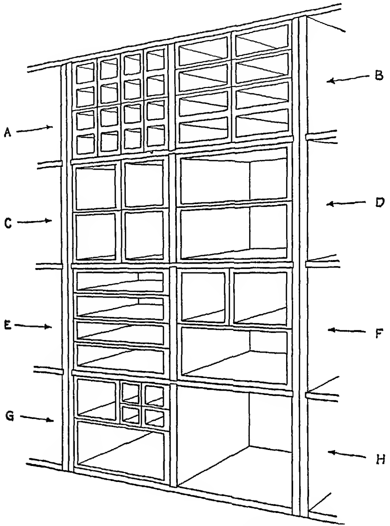
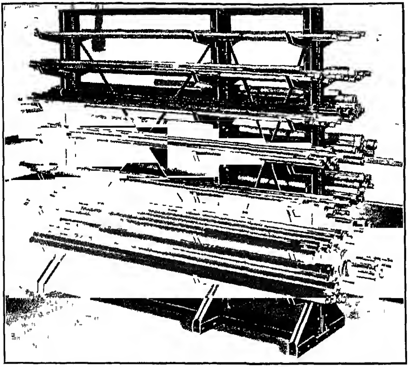


FIG 34 2 Storeroom bin arrangement according to a letter classification

bered, beginning from the bottom Of course the straight numerical systems may be used without letters For the storage of large articles which cannot be placed in bins, the storage floors may have each bay and section lettered or numbered so that the locations may be recorded in much the

same fashion as if the articles were stored in bins The disadvantage of arranging a storeroom by index rather than by classification is that the index must be consulted before an article can be found If the stores are well controlled, this is not important, for the bin location can be inserted on the stores issue at the time it is written Another disadvantage is that



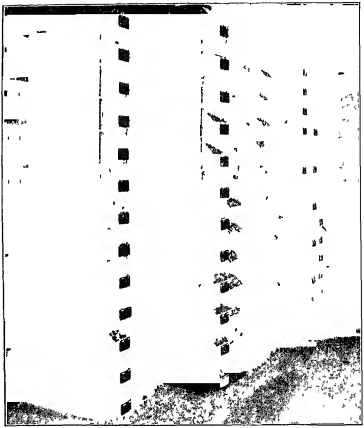
Courtesy Berger Manufacturing Division Republic Steel Corporation Canton, Ohio

FIG 34 3 Pipe rack

the men filling orders, especially when the parts handled are dirty, have difficulty in keeping the index cards clean and usable The advantages claimed for the arrangement by index are (1) stores can be so arranged that those which move fastest are nearest the points of receipt and issuance, (2) no rearrangement of the storeroom is necessary as new articles to be stored are brought in or storage of certain old articles are discontinued, and (3) goods can be stored with full regard for their special requirements

Types of bins Wherever possible, and always where large numbers of small articles are handled, racks containing bins should be placed back to back, making material accessible from aisles running between the rows and thereby economizing storage space Both wooden bins and steel bins con-

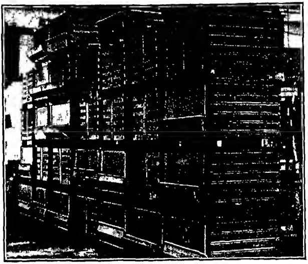
stitute very satisfactory storage arrangements When standard lots of small materials are frequently issued, the idea of using tote boxes and skid boxes as bin compartments or storage racks should be considered Figures 34 4–34 6 show tote boxes, skids, and steel bins Steel shelving occupies



Courtesy, International Detrola Company, Detroit

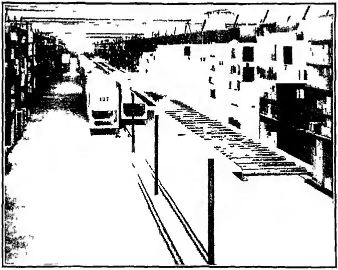
FIG 34 4 Tote pans used for storage in the storeroom

less space than does wooden shelving, but it is more expensive The original cost of the steel bins per cubic foot of storage space will ordinarily be higher than that of wooden bins The better appearance and the sanitary and fireproof features of steel bins often cause their adoption Figure 34 6 illustrates a well-laid-out storeroom utilizing steel bins The skid tote boxes (Fig 34 5) can be taken to the machine when the material is used Likewise they may be filled at the machine where the part is made and stored until needed These steel shelves (Fig 34 6) are being used in a



Courtesy The Powell Pressed Steel Company Hubbard Ohio

FIG 34 5 Steel tote boxes that can be used for storage in tiers or at the machine where operations are being performed



Courtesy, Berger Manufacturing Division Republic Steel Corporation Canton Ohio

FIG 34 6 Steel bins in a drug warehouse

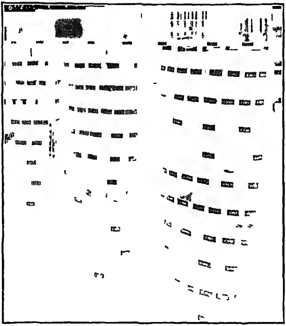
drug wholesale house The central roller conveyor is used for large cartons in order filling The angle iron on the floor on each side of the roller conveyor guides the wheels of the "picking" trucks as orders are being filled Although such bins are of varying sizes, they are rarely changed,

Courtesy Carrier Corporation, Syracuse, N Y

FIG 34 7 Carefully indexed racks in master crib make it easy to find just the right tool for the job

after being set up, except by inserting or removing dividing partitions The rows are composed of standard steel shelving Figure 34 7 illustrates an orderly arrangement of small tools and supplies in special wooden racks and bins Figure 34 8 shows an efficient method of storing small parts that can quickly be located by turning the bins that rotate Many materials, such as bar stock and automobile drive shafts (see Fig 34 9) cannot be

stored in the type of bins illustrated, and special provision must be made for their storage Bar stock is sometimes stored by placing it horizontally on the sides of racks (Fig 34 3) Automobile drive shafts are ordinarily suspended on special racks to prevent bending Special storage also includes storing articles in the original or shipping package Where there is a heavy turnover of small articles and the container fits in with the general



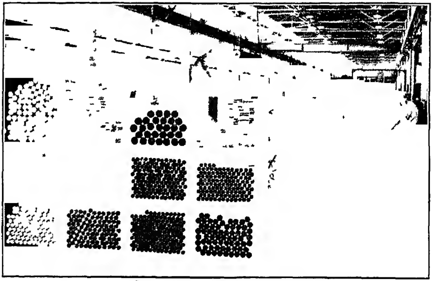
Courtesy Buckeye Tool Corporation Dayton Ohio

FIG 34 8 Revolving bins for storing small parts

storeroom scheme, it is sometimes advisable to store the articles in their original containers On the other hand, this practice must be carefully controlled, since it is usually cheaper to break original packages when they are received than when the storeroom men are in a hurry to make issues Many items may not be opened in the storeroom but may be sent to the assembly line in the original container

A few storerooms use the double-bin system, providing two bins for each type of material It is evident that the double-bin system requires more space, but those who use it believe that this additional space is not a serious enough factor to overbalance the advantages in its favor The double-bin system provides an "in" and an "out" bin for each article While the material in the "out" bin is being drawn for use in the factory, newly received

goods are being placed in the "in" bin When the "out" bin is empty, withdrawals are begun from the other bin, which is now tagged "out," and the empty bin becomes the receiving bin The double-bin system prevents the accumulation of old material in the bottom of a bin, since it is used up before the new material is issued This feature is of special benefit with material which is likely to deteriorate Another advantage of the system is that it provides a continuous physical check on the material to



Courtesy Reliance Electric & Engineering Company Cleveland Ohio

FIG 34 9 Steel is stored in racks near the place it is used

compare with the records, and this check can be made and is made each time one of the bins becomes empty This system is successful only when the kinds of materials carried in stock are more or less constant When the amount of material of a given kind changes considerably, or the material is carried only intermittently, the single-bin system is generally better because of the saving of floor space The single-bin system is far more extensively used Most of the advantages of the double-bin system for small items may be secured by placing the minimum quantity from the new shipment in a small bag The old material may be emptied into a container, the new material put at the bottom of the bin, the old material placed on top to be used first, and the small bag of minimum quantity placed in the back of the bin Occasionally bins with a sliding partition similar to the partition in a letter file are used The old material is placed in front of the sliding partition and is used first

Issuing material Material should be issued from the storeroom only on a duly signed "stores-issue" request This "requisition" or "issue" form should have room for the date, signature of authorizing person, order number against which it is to be charged, symbol of items issued, quantities issued, and any other information needed by the balance-of-stores ledger keeper or the accounting department The storeroom should receive the issue ticket from the balance-of-stores clerk in sufficient time to enable it to prepare the material for issuance to the work place in the factory, so that no delay will be encountered between the existing job and the new one

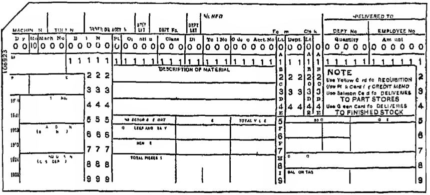


Fig 34 10 Stores card for use in tabulating machine

Some production-control systems call for the department clerk or foreman to write a requisition that is presented directly to the storekeeper In such systems the storekeeper forwards the requisition after it is filled to the balance-of-stores clerk For purposes of accounting and simplicity of storeroom operation, some companies use two different forms for issuing purchased materials and "worked materials" produced within the plant Other organizations use the same form for both types of materials Figure 34 10 illustrates an effective type of card to be used in connection with tabulating machines If this system is utilized, all cards may be printed in the same manner, and their various uses designated by varying colors

A group stores-issue form is used advantageously for parts covering an entire assembly The use of such a form materially reduces the clerical work of issuing orders The exact details of the form are determined largely by the individual enterprise, but it usually contains the same information used on a form for one item only As a matter of fact the same form is often used either for one item or for a group of items Some manufacturers prefer to have only one item on each stores requisition The additional clerical work required can be justified only when special use is made of each

requisition form The "automotive type" of stores issuance makes use of a blanket materials order instead of individual types Material is sent to the assembly line in accordance with the schedule for assemblies Irregular items are handled on special requisitions

Keeping records in the storeroom A positive check to insure that articles on hand will not fall below the designated minimum can be provided in the form of a bin tag on which records of receipts and issues can be maintained If a separate bin tag is utilized for each lot received and issues are deducted from the tags, sending bin tags which read zero to the balance-of-stores clerk may prove a valuable check Figure 34 11 illustrates a very satisfactory form of bin tag To be effective it must be simple, because of the usual nature of storeroom labor It must not be necessary for the storekeeper to keep a running record on bin tags when a balance-of-stores record is kept Sometimes the balance-of-stores record is kept in the storeroom but more often it is kept by the production-control office

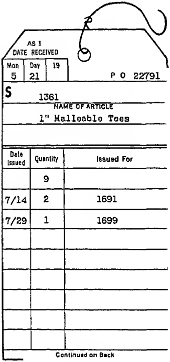
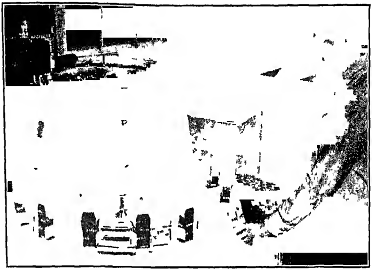


FIG 34 11 Bin tag

Auxiliary storeroom equipment Figure 34 12 shows an electronic counter and packaging machine that can count and box 13,000 small parts an hour It can be adjusted to handle 2000 different parts This type of equipment is particularly valuable in service-parts stockrooms of automobile companies that are shipping parts to dealers Various types of material-handling equipment have been developed particularly for storeroom use In nature they are similar to the material-handling equipment for general use described in Chapter 13 Counting scales, appropriate push trucks for collecting material from the bins, and similar aids facilitate storeroom operation

Ordering materials For special unclassified materials requisition will usually be made directly by a department head, although the approval by the balance-of-stores clerk may be made necessary to prevent duplication of items After receiving the requisition, the purchasing agent makes the purchase and then sends a copy of the purchase order to the storekeeper to

serve as a basis for identifying and checking material when received In order that accurate count on incoming goods may be assured, some plants do not enter the amount ordered on the copy which goes to the storekeeper Goods are ordered by the purchasing department, either upon their own initiative, or, in procedures such as we have described, on the requisition of the balance-of-stores clerk



Courtesy 'Automobile Facts and Buick Motor Company

FIG 34 12 An electronic packager that can count and box up to 13,000 small parts an hour Equipped with 18 electronic tubes and 2 electric eyes, it can be adjusted for handling 2000 different parts

Receiving stores material All material received from outside sources should be turned over to the receiving department, which may or may not be under the control of the storekeeper If articles are delivered directly to the department for which they are ordered, in many instances the receipt will not be recorded, which will lead to difficulty when the invoice is received The date received, order number, weight, number of packages or bundles, charges, whether prepaid or collect, and other necessary information should be recorded, so that a check can readily be made with the invoice As soon as a shipment is received, the storekeeper should refer to his copy of the purchase order He should be responsible for the count and ordering of inspection of all materials received Theoretically, these procedures should take place before the goods are accepted and receipt is made However, in order to facilitate receipts by truck, delivery receipts are often signed as follows "Received subject to count, weight,

and inspection Signed______ " In this event the contents are carefully checked and inspected at a convenient time As soon as the material has been checked by the receiving department, a comparison should be made with the copy of the purchase order Word should be sent to the purchasing department, stating the quantity of material and the general condition in which it was received Such a report is usually termed a "Notice of Arrival," one copy of which goes to the inspection department as a notice that inspection is needed [1] In large plants representatives of the inspection department are part of the receiving-room staff

The inspector fills out an inspection report indicating that the material is according to specifications or indicating rejections with the causes One copy of this report should go to the accounting and one to the purchasing department to serve as a guide for the checking and payment of the invoice Where it is obvious that the material has been damaged or partly lost in transit, notice should be sent to the agent of the carrier to inspect the material This procedure will facilitate matters if a formal claim is to be made Receipts of material in excess of the amounts called for on the purchase order should be tagged "Overshipment," with proper identifications, and placed to one side to await final disposition A rejection tag should be placed on damaged or incorrect shipments It is essential that *descriptive data, such as purchase order number, incorrect report number, kind of material, and similar information, be stated on it* When the inspection report has been received, the storeroom should make out a "Material Received" report,[2] preferably in quadruplicate and signed by the storekeeper One copy should go to the balance-of-stores clerk who will check against the purchase order and make proper entries on the balance-of-stores sheet One copy should be retained by the storeroom, and copies should be sent to the purchasing department and the accounting department to serve for checking invoices

The storeroom receives material from processing in the plant essentially in the same manner as material purchased from vendors, except that no inspection will be needed, and the form on which receipt will be reported will ordinarily be a "Worked Materials Received" slip, rather than a "Stores Received" slip

Handling material returned from the shop With proper methods of issuing, usually only the exact quantities of material needed will leave the

[1] Frequently the inspection department verifies the count claimed by the vendor, thus relieving the storekeeper of counting This often is the most efficient method, since it frequently prevents duplicate handling

[2] The inspection report is sometimes substituted for this report The inspection department in this event sends a copy of its report to the storeroom and all the persons to whom the ' Material Received" report would go

storeroom, but it is possible at times that overissues must be made The simplest method of handling overissues is to have the storekeeper attach a tag marked "Surplus" to the article and retain a copy If the surplus amount is returned, he destroys all records, but, if the surplus amount is not returned from the shop, he makes out an issue slip and sends it to the balance-of-stores clerk to be properly deducted from the amount on hand and to be charged to the proper accounts When materials are returned, the storekeeper makes out a "Stores Credit" and sends it to the balance-of-stores clerk This slip serves to credit the order to which the materials were charged and goes to the cost-accounting section for that purpose, after the proper entries are made on the balance-of-stores sheets

The storeroom personnel The size and nature of the storeroom organization will vary with the size and type of business and the kind of material to be handled Thus it may consist of one man known as the storekeeper, who may give all or only part of his time to the work, or it may consist of a force of men giving full time Even the small plant should place the storeroom in charge of one person For instance, it may be quite possible to assign an office employee to the storeroom for a certain length of time each day By establishing certain hours in the morning and the afternoon, this clerk can take care of all calls for material At other hours he can attend to his regular work in the office Some companies have met the situation by placing a workbench in the storeroom at which a worker is engaged while not devoting his time to storeroom work One manufacturer having only 40 men placed the storeroom and tool crib in charge of a man who also had charge of shipping and receiving

35 · PRODUCTION CONTROL

Definitions. Production control is the process of planning production in advance of operations, establishing the exact route of each individual item, part, or assembly, setting starting and finishing dates for each important item, assembly, and the finished product, and releasing the necessary orders as well as initiating the required follow-up to effectuate the smooth functioning of the enterprise. *Planning department* is frequently used synonymously with *production-control department* or *production department*. It is possible to have a production-control department with little or no advance planning other than the setting of delivery dates. Planning is the function of looking ahead, anticipating difficulties, and taking steps to remove the causes before they materialize. A complete program of production control starts with planning and makes this planning effective through coordination and follow-up. *Routing* includes planning where and by whom work will be done. The *routing* work of a planning department *prescribes the path which work will follow and the necessary sequence of operations,* particularly in building up an assembly product. This work involves such close analysis of facilities that frequently layout is affected. In quantity-production plants, where machines can be set up so that each performs one or several operations in direct sequence, the routing section must have at its disposal all the standards that have been set by job study for the operations and for shop methods. *Scheduling* involves *establishing the amount of work* to be done and *the time when* each element of the work will start, or *the order of work*. This includes allocating the quantity and rate of output of the plant or departments and also the date or order of starting of each unit of work at each station along the route prescribed. *Dispatching* involves the *meeting of schedules by proper utilization of machines, work places, materials and workers, as designated by the routing*. The dispatching unit of the planning department thus includes all persons whose duty it is to see that orders are issued to the shop, that materials are at the work place, that tools are provided, that job cards are issued, and, in general, that all necessary steps are taken to insure that the schedules will be properly carried out.

Routing is usually determined in the first instance by the methods department, but the route, once established, is actually controlled or directed by the orders issued by the production-control department Production control should be clearly distinguished from the function of actually operating the enterprise The production-control superintendent is not the operating superintendent He is the head of an auxiliary staff department that specializes in planning, scheduling, and dispatching as an aid to the operating departments It is unfortunate that many persons who are not familiar with actual operations confuse industrial management or factory management with production control or production management In a scientifically run enterprise production control is an important phase of industrial management, but it is only one element The factory-management group is nearly always the line operating group, to use organizational terminology, whereas the production-control group operates as a staff group

Why have production control as a separate function? Frederick W Taylor is not only the father of modern cost control but also of production control He recognized the advantage of specialization of functions Two of his 8 functional foremen were the order-of-work, or route, clerk and the instruction-card clerk The work of these 2 clerks has been taken over by the modern production-planning and control department In its simplest form production control consists of taking bills of material or specifications to the shops and giving them to the foremen to use in making up the product Such bills of material usually originate in the office of the superintendent, and it is to him that the foremen are accustomed to look for advice in manufacture and for information concerning which job should be done first The superintendent's office, sometimes called the factory office, becomes the center of information regarding jobs to be done and the general sequence in which they are wanted Attention is given a particular order while in process only as pressure is applied by the sales department Pressure is then put upon this order by the factory office, whose representative may frequently be seen walking over the production floors and looking for the order or its component parts When the order is found, everything else is pushed aside to give it precedence, the requirements for delivery on other orders are forgotten or disregarded An organized production-control department avoids most of these delays and expenses

Production control is not confined to the factory The basic function of routing work and scheduling must be performed in the bank, wholesale house, department store, mail-order establishment, railroad, army, navy, governmental agency, or any other type of organization where many people work together (Fig 35 1) The scheduling and controlling of take-

offs and landings of any big airport is an illustration of the need for a high order of control When instrument landing is required schedules have to be expected The aim is to follow an established plan, but adjustments

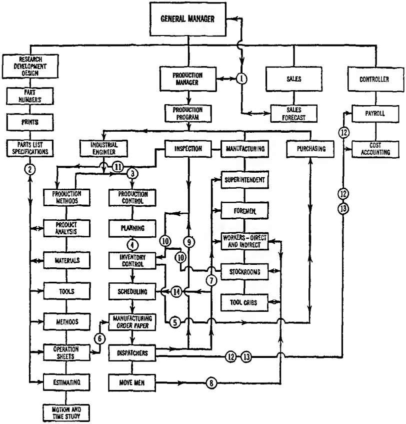
Courtesy United Air Lines Chicago Illinois

FIG 35 1 Filing merry-go-round United Air Lines' reservations agents at Denver are shown using new Motorack which has 126 files suspended from electrically driven belts Files, arranged in sequence by days, each contain 13 trip charts on which reservations are entered Agents answering customer calls obtain correct file by pushing toggle switches which actuate belts right or left Space to record reservations on 1638 upcoming flights is provided Especially developed for United, the company reports that Motoracks increase agents' efficiency by as much as 50 per cent

must be made to meet emergencies It is easier to make infrequent temporary adjustments than to run an enterprise on the basis of one adjustment after another

No work is performed by the well-organized planning department which should not be performed by someone under any type of organizational setup The centralization of all planning work insures not only that it will be done, but also that it will be done by qualified persons in a way

which will be of most benefit to all within the organization The planning department provides an opportunity for the accumulation of centralized knowledge and a utilization of this knowledge (Figs 35 2 and 35 3) To establish a planning department involves taking over from line members



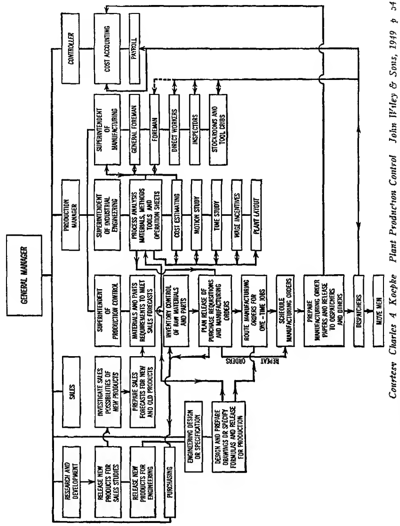
Courtesy, Charles A Koepke, "Plant Production Control John Wiley & Sons, 1949, p 53

FIG 35 2 Chart showing the flow of information between various groups which can contribute to effective production control

of the organization control over (1) when work is to be done and, within limits, (2) where work is to be done The extent of control that this department may exercise over these phases of the plant's activity must necessarily vary with the plant and the product

The evolution of production control The early production-control efforts consisted largely of a master schedule with shipping dates Each department head, with delivery dates in front of him, strove to push through

the items in order to make shipping deadlines (Shipping dates still remain the controlling data for modern production control) Orders thus take precedence on the basis of the date when they are wanted The crea-



Courtesy Charles A Koepke Plant Production Control John Wiley & Sons, 1949 p 54

FIG 35 3 Chart showing the interrelationships between production control and other groups and departments

tion of such a schedule implies the development of a manufacturing-order system The orders are issued at such time that the work upon them may be completed by the schedule date, but the time of starting work on them is usually left to the foremen of the departments These orders usually have priority on some such basis as the following

1 Customers' orders which require special attention to meet the promised date of delivery
2 Repair orders accompanied by an urgent request for delivery
3 Customers' orders that will ordinarily come through on time for the promised date of delivery
4 Routine repair orders
5 Orders for goods to be placed in stock

Stock chasers or follow-up men are needed to push orders through the plant They smooth out difficulties that may imperil the master schedule as soon as they are seen to develop The causes of shortages or delays may also be investigated, and an attempt made to prevent their recurrence These stock chasers or follow-up men may be organized on the basis of the *customer's order* or *related departments* When organized on the basis of the customer's order, each stock chaser follows an order or a group of orders all the way through the plant When organized on the basis of related departments, each follow-up man follows all orders in his respective unit or department This simple form of production control, using stock chasers to meet delivery dates, endeavors to anticipate delays and eliminate their occurrence, whereas the older method strives only to correct them after they have occurred

The functions of a complete production-planning and control department The comprehensive production-control program presupposes the centralization of responsibility for

1 The manufacturing orders
2 The material for these orders
3 The productive equipment, including machinery, tools, and work places to be used
4 The workers, in so far as priority of work is concerned

In the simple production department a large share of the delays in production is ordinarily due to ineffective operation of staff functions which relate directly to production Such functions include shop transportation, toolroom operation, maintenance of equipment, and superintendence of raw materials and partly fabricated stores It therefore frequently becomes logical to place the supervision of several of these functions in the hands of the production department in order to correlate its activities with each other and with the necessities of the production program

The production-control department seldom actually has control of the equipment, it usually issues orders on the maintenance department to have the equipment ready In a few cases it establishes priorities for the work of the maintenance department Seldom does the production-control department have any direct control over the workers, but it schedules work to the machines, leaving the assignment of a particular worker to the dis-

cretion of the foreman The production-control department in some instances has control of the departments handling material and in others merely issues the orders on another department that handles the material

The production-control department receives orders from the sales department or operates according to a master budget, it takes all the steps necessary to see that the product is shipped according to the promised dates The orders are the authorization for the performance of the work, and issuing them carries with it an implication of coordination with the sales and financial aspects of the business The material comprises everything upon which work is to be done, whether it be raw stores, worked material, or components which are the product of another plant The productive equipment comprises all machines, tools, and work places within the factory which are utilized for manufacturing purposes, and its control implies its utilization for such productive work as may be deemed best at a given time All these factors are coordinated by the planning department so that a series of operations based on needs of the manufacturing orders, upon capacities of equipment and workmen, and upon condition of material are developed These operations are then laid out, supervised, and correlated in such a manner that work will proceed through the plant in the smoothest and most orderly fashion

The organization of the production-control department The interrelationships of various production-control activities are illustrated by Fig 35 4 Regardless of the actual lines of authority, the planning department must work in close cooperation with the following departments cost, purchasing (Fig 35 5), standards and methods, plant layout, tool, factory maintenance, inspection, stores, shop transportation, finished stock, sales, and shipping (Fig 35 6) Many of the data used by the cost department are collected by the planning department Purchases are often made on requisitions from the balance-of-stores ledger clerk Planning is accomplished through the use of data supplied by the standards and methods department Plant layout largely determines the routing and sequence of operations, especially in line production Shop transportation of materials and product is usually done on order from the planning department The availability of finished stock and the inventory of finished stock are directly tied in with the plant's schedule Customers' orders originate with the sales department but must be scheduled by the planning department unless filled from finished stock (Fig 35 7) The sales department gets its promises for delivery dates from the planning department, which relies upon the tool department for tools used in production and cannot schedule actual operations until the tools are available The keeping of scheduled promises is intimately associated with the maintenance of equipment in running

order Inspection in many instances is an operation in the production sequence and must be scheduled just as other operations

The specific organizational structure and location in the over-all organization of the production-control function are influenced by the type of operation, the organizational philosophy of top management, and the standing

PRODUCTION

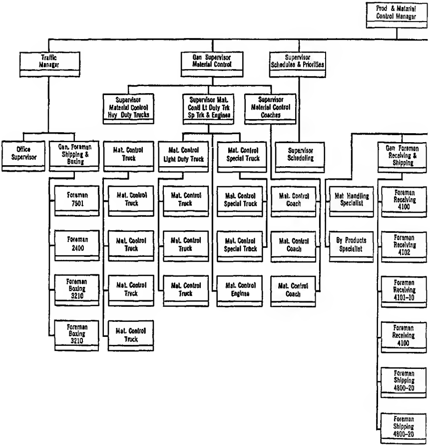
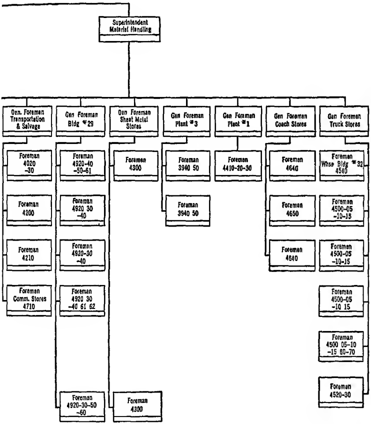


FIG 35 4 Chart showing the production-control

of the person in control of this function, as well as the size of the operation As an illustration of the influence of personalities, in one large company all internal and external transportation, material handling and storage, stock records, and tool cribs are under the charge of the production-plan-

ning and control department In turn the department answers to the purchasing agent, who is a vice-president This is an unusual arrangement, but it works successfully If this same vice-president had come up through production control, purchasing, in all probability, would have been a division of production control



Courtesy, GMC Truck & Coach Division, Pontiac

division of General Motors Truck and Coach Division

Planning problems in clothing and metal-cutting manufacture or in paper and standard textile manufacture are essentially similar But planning for production in a flour mill has few similarities to planning in a watch factory In continuous industries manufacturing standard products on a

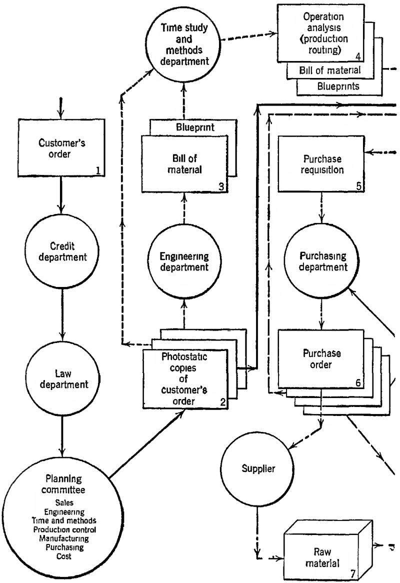
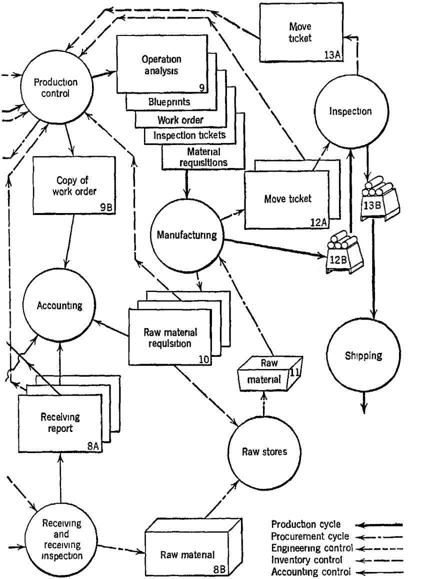


FIG 35 5 Chart of job-order planning



Courtesy E H McNiece Production Forecasting Planning and Control John Wiley & Sons 1951 p 23

in a heavy machinery company

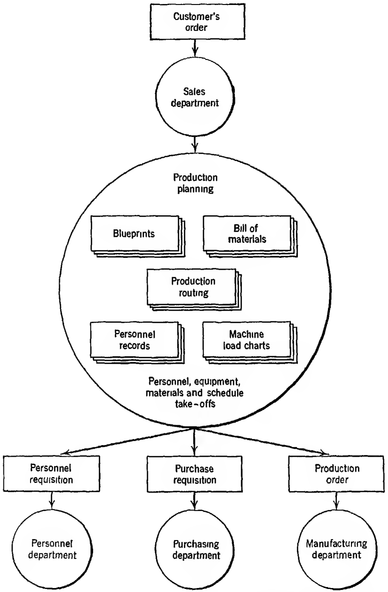
quantity basis the scope of the production or planning department is far different from what it is in the jobbing shop By giving adequate consideration to plant layout in continuous industries, the problems of routing and dispatching between operations have been eliminated to a great extent It is to the schedules that most planning attention must be given in such plants In assembly industries manufacturing diverse products the most involved planning-department organization is found

Courtesy Studebaker Corporation

FIG 35 6 Production coordination starts when the executive vice-president (standing) meets with the key men of his manufacturing, industrial relations, and purchasing staffs

From a purely organizational setup it would appear that production planning and control, inspection, manufacturing, and plant engineering might well be coordinate departments answering to the general factory manager This arrangement would, of course, imply that each of these divisional heads would be thoroughly qualified to carry the load of his division Too many production-control men have had little or no operating experience, hence their approach is largely clerical Under these circumstances it is but natural that the position of the superintendent of production planning and control is not on the same level with that of the superintendent in charge of manufacturing Neither would such a man be likely to be placed in charge of receiving, shipping, material storage and handling, or transportation

A central department correlates the activities of the various individual planning units, which are usually located in each of the producing depart-



Courtesy E H McNiece "Production Forecasting Planning and Control" John Wiley & Sons 1951 p 19

FIG 35 7 Chart showing the general arrangement for job-order planning

ments of the plant Under decentralized control the over-all department schedule is determined by the central planning department, but the details are worked out by the individual planning unit within the department (when there is one) or by the foreman in the absence of a representative of the planning department In small concerns centralization is without question the desirable ideal, but in large factories decentralized control is usually found

The planning clerk in each department may report either directly to the foreman or to the planning department In either case he will report to the central planning department functionally By this system the central planning department retains essential control of production from raw materials to finished stock, and at the same time in large plants its schedules and plans become more flexible and more readily adjusted to day-by-day and hour-by-hour happenings in the shop This type of planning control merely provides for the moving of some of the detail-planning work to the departments, without in any way reducing the correlation of major activities of the plant The central planning department still controls the schedules and the dispatching [1] between departments The planning supervisor in each department controls dispatching within the department Routing may be carried on in the place which seems most desirable under given plant conditions Decentralization of planning control brings with it relief from certain dangers against which centralized control constantly must guard It is easy to get out of touch with departmental or plant conditions It is easy to lose the cooperation of the foremen and subforemen upon which depends, in a large measure, the success of planning work Although with central control the foremen should be in and out of the planning department all day long, decentralized control enforces the aid of foremen in planning Thus, not only are the data collected by the experts of the planning department available, but also the mass of technical information concerning production which has been accumulated by the foremen through long years of direct contact with the job can be utilized In modern mass production there is a definite trend toward decentralized planning control

Factors needed to make production control successful A modified form of production control may be reasonably successful without the following requirements A detailed and effective production-control system requires organizational structures, reliable information, a relatively high degree of standardization, and trained personnel as follows

[1] Special move orders need not always be issued by the central planning department unless it is from a central storeroom of partly fabricated parts, even then those orders may be quantity orders rather than orders for each load Dispatching may be carried on by the department planning unit as soon as the work is finished in the given department In the "flow type" of manufacture many planning details are minimized

1 Reliable information concerning requirements and productive capacities
  1 1 Knowledge of products required to be produced A master schedule of production required from the sales department is highly desirable When production is to customer's order, the schedule may be built by the planning department from the individual orders
  1 2 Detailed information about the number and types of each production machine and processing unit, together with the feeds, speeds, and productive capacities In addition to the capacities, it is necessary to know the available time not scheduled in the case of intermittent manufacture
  1 3 Detailed information concerning the manufacturing time required and the sequence of operations for each part going into the finished product and for the finished product as a whole
  1 4 Detailed information concerning material requirements, amount on hand, amount required, length of time to get delivery for items purchased, and quantities used per unit of production
  1 5 Detailed information concerning the available labor in the shop and the productive capacities of the men
  1 6 Complete information concerning the manufacturing operations for each part, the proper tools, jigs, and fixtures for each part, and their availability
2 Standardization
  2 1 Materials purchased and fabricated
  2 2 Operations on all parts as far as design permits
  2 3 Tools and equipment as far as practical
  2 4 Procedures of operations and organizational setup, including delegation of authority and fixed responsibility
  2 5 Production standards for employees and method of remuneration for employees
  2 6 Quality requirements and adequate inspection to guarantee quality maintenance
  2 7 Reports on production performance in comparison with scheduled production
3 Organization
  3 1 Recognition by management of the need for production planning and willingness to delegate authority with the responsibility
  3 2 Recognition by the supervisors whose work schedules are being centrally determined that this is merely an extension of functional specialization which makes possible their devoting more of their time to those activities for which they are best qualified This attitude produces cooperative effort
4 Personnel
  4 1 That understands the operations that are scheduled
  4 2 That is trained in the requirements of the particular system being used
  4 3 That possesses the aptitude and interest in doing the required work
  Production control requires planning, clerical, and operational capacities

Summary. The production-control function must be performed by someone To set it up as a separate function merely makes use of the *principal of specialization* It is not necessary that the small plant have a different person perform each function that has been or will be described

Sales Forecast

Item	J	F	M	A	M	J	J	A	S	O	N	D
10-28	850	880	700	700	600	700	700	900	950	850	850	700
10-30	630	630	600	600	600	600	600	700	700	750	750	600
20-60	500	500	500	500	500	500	500	600	600	650	600	720
20-80	960	900	900	850	850	850	850	900	900	900	900	900
30-10	350	350	350	200	200	200	200	350	350	375	375	350
30-15	700	700	700	700	700	700	700	700	800	800	700	700

±

Difference in Finished Goods Inventory + Minimum Balances

=

Production Routing

Part No 284 B

Operation	*Man-hours*	*Machine-hours*
1 Punch	0 53	0 53
2 Mill	0 70	0 70
3 Drill	1 50	3 00
4 Weld	0 26	0 52

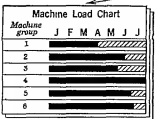
Master Production Schedule

Item	J	F	M	A	M	J	J	A	S	O	N	D
10-28	600	850	700	700	700	700	700	800	800	800	800	800
10-30	700	650	650	650	650	650	650	650	650	650	650	650
20-60	400	500	500	500	500	500	600	600	600	600	600	600
20-80	800	900	900	900	900	900	900	900	900	900	900	900
30-10						400	400	400	400	400	400	400
30-15	700	700	700	700	700	700	700	700	700	700	700	700

Bills of Materials

Part No 284 B

EDDAB 16 ga 0 3 lb

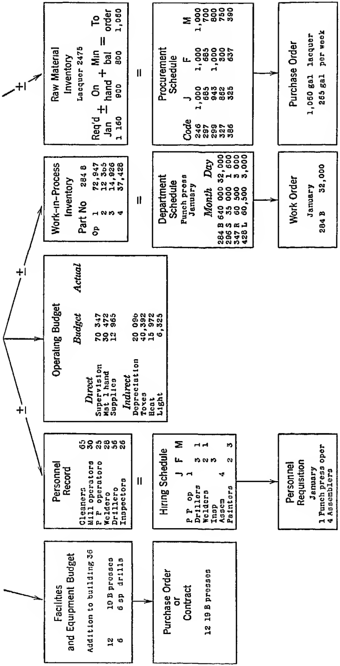


Personnel and Equipment Breakdown

Department	*Man shifts*	*Machine shifts*
Punch	2 659	1,748
Mill	1,478	1,478
Drill	10,943	8,093
Weld	4,692	3,247
Sub assembly	9,076	3 048
Final assembly	11,492	480

Material Breakdown

2" cold rolled B	26,000 lb
16-ga EDDAB	36,000 lb
1/16 needle bar	765 lb
5/16 18 1/2" cap screws	9,040 lb
Primer brown	7,042 gal
Lacquer 247 S	14,000 gal
2" x 4" dunnage	3,000 B F



Courtesy E H MacNiece "Production Forecasting Planning and Control" John Wiley & Sons 1951 p 16

FIG 35 8 General planning arrangement for manufacture to stock

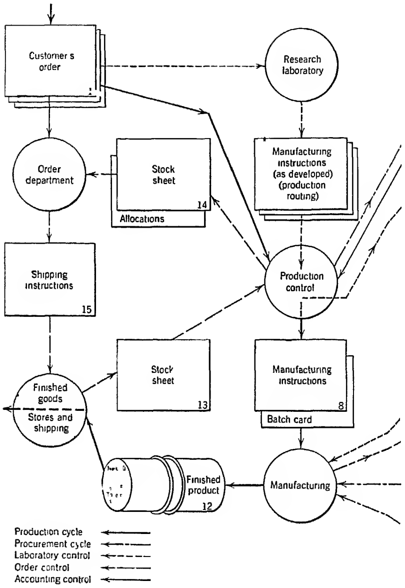
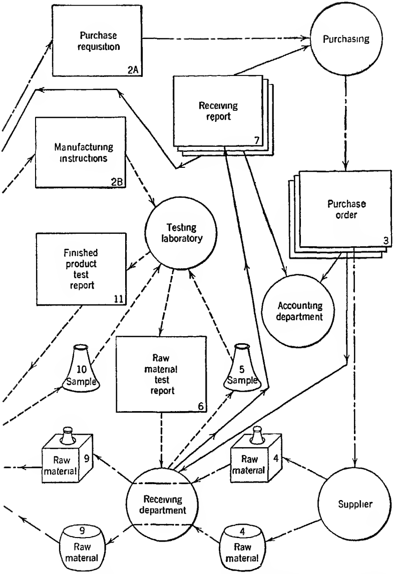


FIG 35 9 A typical planning and control



Courtesy E H McNiece Production Forecasting Planning and Control, John Wiley & Sons 1951 p 21

organization in a chemical company

On the other hand, in large establishments many workers are needed to handle the detail of planning No fixed number of persons or fixed arrangement of functions is possible in organizing a planning department (Figs 35 8 and 35 9) Production planning is the answer to greater production on the same investment without unduly speeding up workers Effective planning always means effective control of detail It is this detail, properly coordinated, which makes not only for an even flow of production but also for accurate costing The advantages of production control may be said to include the following points

1 Better service to customers, in that promised delivery dates are kept

2 Fewer rush orders in the plant and less overtime than in the same industry without adequate production-planning control

3 Lower inventory of work in process

4 Less finished stock required to give the same service to customers

5 Better control of raw material inventory which contributes to more effective purchasing

6 More effective use of equipment

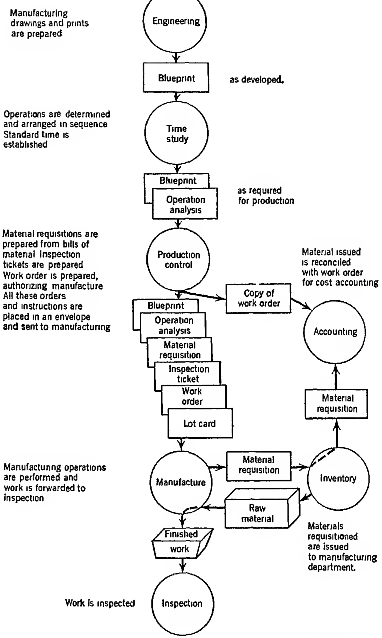
7 Less loss of time by workers waiting for materials, with improved plant morale as a by-product

36 PRODUCTION CONTROL ROUTING

Routing The routing function most clearly distinguishes the work of the planning department from that of the simple production department (Fig 36 1) The automobile is a product in the manufacture of which the various phases of production control, routing, scheduling, and dispatching have been highly developed The finished car is essentially an assembly of various parts manufactured and brought together as subassemblies The raw material comprising each of these components must be put through a number of manufacturing operations before being available for subassemblies, and decisions must be made concerning the most economical operations and machines for the manufacture of each component with due consideration for other current demands on the workmen and equipment of the shop On the other hand, some manufacturing is so extremely simple and the product is so uniform that only a very simple routing mechanism, if any, is required after the plant once begins operations For instance, a flour mill which operates day after day and year after year on the same kind of raw material, turning it into the same type of finished product, will have but little need for an elaborate system of routing

Routing is a technical function in the first instance and is originally performed by the methods or engineering department From the standpoint of the production-control department routing includes *the planning of where and by whom work shall be done, the determination of the path that work shall follow, and the necessary sequence of operations,* it forms a groundwork for most of the scheduling and dispatching functions of a planning department Only the development of the master schedule and the issuance of manufacturing orders precede it Routing may well be subdivided as follows

1 The analysis of the finished article from the manufacturing standpoint, including the determination of components if it is an assembly product Such analysis must indicate the materials or parts needed, whether they are to be themselves manufactured for an order or whether they are to be found in stores either as raw or worked materials, or whether they will have to be purchased, and the quantity of materials needed for each unit and for the entire order Much of this work may have been done by the engineering or design department in drawing up the specifica



Courtesy J H McNiece Production Forecasting Planning and Control John Wiley & Sons 1951 p 68

FIG 36 1 A production-routing procedure

tions for the product, but these must be studied and checked from the production standpoint

2 The fixing of the sequence of completion in manufacture that one part, or piece of material, bears to another, in order that all may be brought together as needed in the process of manufacture

3 The determination of the operations which must be performed at each stage of manufacture, and the place where these shall be performed This implies a division into such operations as will utilize to the best advantage both the skilled and the unskilled members of the production force and all equipment It is here that the results of job studies are of great importance The actual selection of machines and workmen after operations have been determined is the portion of the routing function that is most frequently performed decentrally

4 The division of total quantities required into proper manufacturing lots or batches This must be done with due reference to length of operations, space occupied by the material while moving through the shop, and the requirements of the master schedule

Plant layout, routing, and symbols used for identification Layout by product facilitates inventory and production control This type of production control is known as "flow control" The essential features of this type of production control are starting the product on a line and having all needed parts available as the assembly proceeds Figure 40 1 illustrates a series of interrelated line controls The plant layout determines to a large extent the route a given part, subassembly, or product will take

Routing from the bill of materials Routing is facilitated by a well-developed system of identification Routing and identification should be interdependent A skeleton identification classification for stores, worked materials, and finished stock is of great assistance in developing routing work Routing will be greatly facilitated if material symbols and operation symbols are so devised that they may be used directly in the work of routing and included in the routing instructions which are issued by the planning department

The bill of materials with proper symbols for identification and the specifications are provided by the engineering or methods department When they are received for a special order or for a product to be produced for stock, the work of the production-control department begins As indicated in Figs 36 2 and 36 3, a list of the components of the product, together with specifications of the materials from which they are to be made, manufacturing tolerances for machined parts, and frequently a list of the operations to be performed on each component, is generally provided The last item may be left entirely to the production forces, but, if it is, close contact must be maintained between the two departments to insure that designs do not involve unnecessary manufacturing complications The complete bill of materials and the specifications constitute a master list from which all production-control data are derived At times the production-control department may have to compile its own lists from those provided

PARTS LIST – MATERIAL REQUIREMENTS

MODEL ASSEMBLY NO 49728 NAME OF ASSEMBLY Steering Heed

LINE	A. B. Dick Part No	Customer's Part No.	PART NAME	First Subassembly	Quan Per Unit	Make Buy M F S	Mat. Furn by D V C
1							
2							
3	24945	1590525	Arm	24953A1	1	M	D
4							
5							
6	24946	1590526	Bose	24947A	1	M	D
7							
8							
9	24947	1590527	Arm	24947A	1	M	D
10							
11							
12	24948	1590528	Ecoentric	24947A	1	F	V
13							
14							
15	24949	1590530	Operating Pin	24947A	1	M	D
16							
17							
18	24950	1590532	Pivot Bearing	24953A2	1	M	D
19							
20							
21	24951	1590534	Pivot Bushing (Short)	24953A1	1	M	D
22							
23							
24	24952	1590535	Reflector End Bracket	24953A1	2	M	D
25							
26							
27	24953	1590536	Refleotor	24953A1	1	F	V
28							
29							
30	24954	1590537	Pivot Boshing (Long)	24953A1	1	M	D
31							
32							
33	24955	1590542	Oover Plate	24953A2	1	M	D
34							
35							
36	24956	1590543	Refleotor Support Bracket	24941A	1	S	D
37							
38							
39	24957	1592814	Fillistor Heed Sorew	24941A	3	F	V
40							
41							
42	24958	1590918	Nut	24953A2	1	F	V
43							
44							
45	24959	1591305	Pin		3	F	V
46							
47				24941A	2		
48							
49				24505A2	1		
50							

FIG 36 2

A. B DICK COMPANY
CHICAGO

DATE ORIGINAL ISSUE May 27, 1954 NO 1

APPROVED A E Newman
CHIEF ENGINEER

LEGEND

M = MAKE F = BUY FIN COMPLETE S = BUY SEMI-FIN
D = DICK V = VENDOR C = CUSTOMER

SHEET____ OF ____

MATERIAL DESCRIPTION (MATERIAL / SIZE / SHAPE)	QUAN PER 100 PCS Unit	QUAN PER 100 PCS Quan.	Spec. No	Size Shape Code No.	C. M P Code No.	LINE
						1
						2
Stainless Steel Type 304, 0 0126 ± 0 001	lbs	0 980	94	0528214	2531	3
						4
						6
Aluminum Alloy 52S, 0 0508 ± 0 0025	lbs	0 645	11	0326367	4311	6
						7
						8
Aluminum Alloy 52S, 0 0508 ± 0 0025	lbs	1 819	11	0326368	4311	9
						10
						11
Aluminum Alloy 17ST, 0 3125 ± 0 0015			11	01	4121	12
						13
						14
Aluminum Alloy 17ST, 0 125 ± 0 0015	lbs	0 062	11	0117032	4181	15
						16
						17
Stainless Steel Type 416, 0 156 ± 0 001	lbs	0 325	96	0117042	2501	18
						19
						20
Stainless Steel Type 416, 0 156 ± 0 001	lbs	0 170	96	0117042	2501	21
						22
						23
Brass 1/2 Hard 0 025 ± 0 0017	lbs	1 230	21	0328286	2501	24
						25
						26
Ground Plate Glass						27
						28
						29
Stainless Steel Type 416, 0 187 ± 0 001 Square	lbs	0 695	96	0117497	2501	30
						31
						32
0 0253—0 002 Aluminum Alloy 17ST or 24ST opt	lbs	10 700	11	0128287	4311	33
						34
						35
Aluminum Alloy Die Casting AG 13 or AG 15	lbs		10	01	4207	36
						37
						38
Stainless Steel Type 416 or 410			96	01	2501	39
						40
						41
Stainless Steel Type 303			94	03	2501	42
						43
						44
Stainless Steel Type 303, 0 110 ± 0 0003			94	03	2501	45
						46
						47
						48
						49
						50

Courtesy A. B. Dick Company

Bill of materials

ASSEMBLY PARTS LIST

LEADER MANUFACTURING COMPANY

ASSEMBLY NAME Mieeograph 90 Duplicator DATE 8/25/54

ASSEMBLY NO 15001-A2 ISSUE NO 3 SHEET 14 OF 20

Quanlity Required							Part No	Description	Source
		1					15364	Feed tube guide channel	
		1					15351-A2	Sheet feed raising lever assembled	
			1				3ᵔ08	Roll stop truck	
			1				3209	Roll stop truck rivet	
			1				15351-A1	Sheet faed raising lever assembled	
				1			15349	Sheet feed raising lever spacer	
				1			15351	Sheet feed raising lever	
				1			15352	Sheet feed raising lever hub	
				1			15385	Synchronizing pin for sheet free arm	
				1			21764	Table tripping sector spring pin	
	1						1532oA	Feed driving eccentric assembled	
		2					177J	Flat-head screw #10-32×3/8	
		1					6c36	Roll-locking lever operating arm	
		1					15302	Eccentric ring	
		1					15303A	Feed driving eccentric assembly	
			1				15301	Feed raising arm cam	
			1				15303	Feed driving eccentric	
			2				177C	Flat-head screw #10-32×3/8	
			1				15395	Eccentric clamp screw	
		1					15365A	Feed bell crank assembled	
			1				15365	Feed bell crank	
			1				15366	Bell crank tube push pin	
			1				15381	Feed bell crank rod hub	
			1				15382	Feed bell crank pivot rod	

CHANGED BY													
DATE													

Courtesy A B Dick Company

FIG 36 3 Route sheet combined with an assembly parts list Note the vertical columns at the left The numbers in each column indicate the number of each part used, and counting columns from the left to right indicates the order in which parts and subassemblies go together

by the design department, especially when the work of the various members of the department is functionalized

Additional data needed for efficient production control Naturally a complete detailed specification is needed for any type of modern production On operations which have been previously performed, job-study data should be available, and on new operations job studies must be made and the results reported to the planning department If there is not time for job studies on new operations, then the advice of the job-study man or the foreman must be secured concerning the routing of the work He will be able to give much valuable advice from his knowledge of equipment capacities

If routing to particular machines is to be attempted, some record of available machine capacities must be at hand This may take the form of a rough record of the relative amount of work that is being given to each machine, or it may take the form of the more complicated Gantt chart portrayal of machine load [1] Such a record enforces the consideration of the utilization of all the shop equipment This record quickly indicates the approximate amount of work assigned to each machine or class of machine in the shop In order to promote flexibility of dispatching, alternate machines should be indicated in the routing whenever possible, but any cost advantage in the use of one machine over another should be shown by designating clearly the preferred machine

Route sheets Route sheets have many auxiliary uses in addition to prescribing the manufacturing route for a given item The two main purposes are (1) they indicate, for scheduling and dispatching purposes, the necessary operations to be performed, and the place where they are to be performed, when accompanying material they may constitute the authority to manufacture, and (2) through the check columns they provide a progress report which gives at any time the status of any component, assembly, or order that is in manufacture

The path that a particular item is to follow through production may be recorded graphically or in tabular form on what is known as a route sheet (see Figs 36 2–36 4) These are prepared in advance of need and filed in a *route file* Route sheets list fully the materials that are necessary for a given operation, the complete list of operations in sequence, and the machines on which they are to be performed In addition, for dispatching purposes, the standard time for each operation may be given, and check spaces are provided to record the progress of the order through the shop [2]

[1] See Fig 37 1

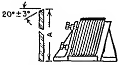
[2] It should be clearly borne in mind that these forms are purely illustrative Each industry s needs and the requirements of each department will govern the exact form and data to be included Production control systems like other management techniques, should be adjusted to the needs of the individual enterprise

Equipment and Tool Name		Part No	
		Tool No	*Req'd*
Cincinnati Milling Machine		STD	1
Yale Skid		STD	2
Clamps—Angle (set)—3		BT-2045	1
Cutter—Spiral Split $2\frac{1}{2} \times 6 \times 14\frac{3}{4}$ (Use scrap cutters if available)		BT-2248	1
Block—Riser		BT-2059	2
Arbor—$2\frac{1}{2}'' \times 42''$		BT-2220	1
Plate—Stop		BT-2221	1
Crow Bar—Spec		BT-2222	1
Coolant—Van Straaton #523		STD	—
Gage—Plate Width	(512)	SPG-20532	1
"	(528)	SPG-31000	1
"	(814)	SPG-20531	1
"	(836)	SPG-20531	1
Punch—Forked		BT-2292	1
Wrench—Double end ($1\frac{1}{8} \times 1$)		STD	1
Hammer—8-lb sledge—dbl -face		STD	1
Bar—Spec pry		BT-2225	1
Wrench—dbl -end ($1\frac{1}{4} \times 1$)		STD	1
Wrench—$1\frac{1}{4}$ socket, right angle handle		STD	1
Brush—Chip		STD	1
Pan—Chip		BT-2250	1
Block—Wood (Steel reinforced to protect machine)		BT-2224	1
Cloth—Wiping		STD	—
Budgit Hoist		STD	1
Spacers—$2\frac{1}{2}''$ dia (set)		BT-4659	1

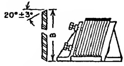
Chg Let	Alteration Made	Date	Chg by	Chk by	Used on Model No	Eng Chg
					836-17C2 836-2C2 814-4&6C3 528-1C2 512-1&2C1 5	

Design	*No of Plates*	"A"	*Tol*	"B"	*Tol*
836	10	14 375"	+ 000 − 070	14 250"	+ 000 − 070
814	10				
528	10	12 407"		12 343"	
512	11	10 905"		10 812"	

FIG 36 4 Operation sheet Note that the instructions are in sufficient detail



First Milling Cut



Second Milling Cut

Operation Procedure

1 Cutter is mounted on arbor to mill conventional The cut begins at stencilled end and progresses toward the tip end of plates
2 Wipe fixture and check to see that it is free of chips and dirt
3 Position end plate on fixture and secure
4 Remove plates from skid and load on bed plate one at a time until all plates are loaded, set plates at proper angle (see chart)
5 Tighten set screws in plate holding fixture
6 Hammer top edges for proper seating of plates
7 Retighten set screws securely and adjust shield
8 Start cutter and turn on coolant Be sure that a steady flow is directed on the cutter while milling
9 Run table at fast speed until stencilled end of plates is within 3" of cutter, then set machine to specified automatic feed
10 Mill plates (see chart for feeds and speeds)
11 Upon completion of cut, reverse feed and run table at fast speed to original loading position
12 Turn off coolant and stop cutter
13 Clean out chips
14 Remove shield and loosen bolts on holding fixture
15 Remove end fixture
16 Loosen plates with bar and remove to skid
17 Clean bed plate and fixture
18 Position end plate on fixture and secure
19 Remove plates from skid and load in bed plate one at a time, milled edge down Set plates at proper angle
20 Follow Procedures 5, 6, 7, 8, 9, and 10
21 After 4" of the plates have been milled, operator is to back plates away from cutter and have inspector check width of plates with gage Make necessary adjustments
22 Follow Procedures 8, 10, 11, 12, and 13
23 Upon completion of entire cut, have inspector check width of plates at center and both ends
24 Follow Procedures 14 and 15
25 Loosen plates with bar and remove to skid

Cutter speed, r p m	40
Feed in per min	4

Note Dimensions = 0 010 unless otherwise specified

Shadow and Tool Sheet

Operation	Mill Plate Edges				Part Name Camber
Met'ds Eng	L A H	11-29-44	Prod Eng	Date	Dept No
Proc Chk	A A W	11-17-44	Met'lrgy Chk	Date	Mat'l Spec S A E 4330
Proc by	H S C	10-28-44	Insp Chk	Date	
Drawn by	S T	10-28-44	Prod Chk	Date	Sheet No 1 of 1
Curtiss-Wright Corp Propeller Division				Plant Beaver	Oper No 880

Courtesy Louis A Hradesky Methods Engineer Curtiss Wright Corporation Propeller Division

so that a beginner can perform the operations with a minimum of instruction

Different types of route sheets are usually needed for components and for assemblies because of the different natures of the operations involved

Assembly route sheets must show clearly the sequence of assembly operations, particularly whether the operation may be performed independently or simultaneously or must be performed in sequence after another assembly operation because it depends on the product of the latter for a portion of its material On an assembly route sheet it is necessary to show what additional material is needed for the performance of each operation and should be supplied at various points in the assembly process "Master departmental or divisional route sheets" are frequently made out in the central planning office and given to the decentralized planning office as a guide This route sheet shows the sequence of operations and types of machines, but not the exact machine unless there is only one of the desired type

Route files The route file including all tickets needed for planning and dispatching work during the course of the order in the shop, such as time and job tickets, requisitions for worked materials and stores, operation orders, inspection tickets, and move tickets or tags, must be made ready These tickets (Fig 36 5), which are usually prepared in the main by some duplicating process (Fig 36 6), are suitably taken care of by some filing scheme until they are needed for dispatching to the plant Sometimes they are all placed in pockets in a specially constructed file, which contains all route sheets and papers pertaining to one manufacturing order Thus in the route file information can be found concerning the path that the order is to take through production, plus all necessary forms which will be utilized in dispatching, working, paying for labor, or recording costs for the order, plus the necessary columns on the route sheet to record accurately the progress of the order To these often will be added tool lists to be sent to the toolroom as given operations are called for in the process of dispatching, and instruction cards to be issued to the workmen as the operations are to be performed Route sheets are at times arranged in the form of a visible index, so that they may be easily referred to by the dispatcher, in this case the necessary forms are filed close by in boxes or tub desks

Punch-card equipment is being used increasingly in production planning and control (Fig 36 7) Master route cards, instruction sheets, and other forms are prepared and filed for future use These master cards cover every phase of production control when a complete punch-card system is used and are not changed until the product or some operation is changed They are made up in advance of use When an order for production is received, these master cards are used to duplicate the necessary forms, orders, and instruction used in production The cards are released to the factory and, when returned, provide data in detail for payroll, cost

PROCESS SHEET SPECIFICATIONS AND ROUTING

SHEET 1 OF 1

PART NO	PART NAME	SUBASSEMBLY USED ON	RELEASE APPROVAL	ENG RELEASE
33018	GUARD	33000	A E N	

WRITTEN BY	CHECKED BY	APPROVED	DATE	DATE RELEASED TO PROD CONTROL
NAVARRO	E J MILLER	H J D	5-31-54	5-26-54

MATERIAL DESCRIPTION	MAT SPEC NO	MAT CODE NO	ENG CHANGE ORDER NO	ENG CHANGE DATE
0 032 × 2 3/8 × 3 3/8 -52-S AL ALLOY (PINK-BLUE)	1103	26333		

OPER NO	OPERATION DESCRIPTION	DEPT	GROUP	MACH.	EQUIPMENT DESCRIPTION TOOL, JIG, GAGE OR FIXTURE NUMBER AND DISCRIPTION	PIECES PER HR	STD HR PER 100 PIECES	CLASS	STD SET UP TIME	NORMAL MCH HRS PER 100 PCS	NORMAL MAN HR PER 100 PCS
1	Pierce and Blank	414	6	517	#3½ Toledo Punch Press Piercing and Blanking P & D	600	0 166	T	0 5	0 166	0 166
					T 41624 Bolster 1003						
2	Form	414	6	1181	#3½ Toledo Punch Press Forming P & D 41625	333	0 300	T	0 5	0 300	0 300
					Bolster 1001 Checking Gauge 49695						
3	Burr and Wash	440			Polishing Jack Tank	200	0 500	T	-	-	0 500
4	Inspect	475			Bench Checking Gauge 49695	200	0 500	T	-	-	0 500
5	Anodize as per Spec #26 (Send Outside)										

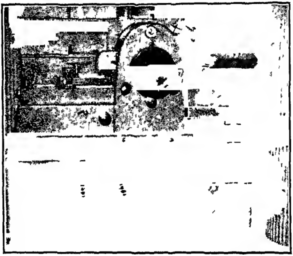
DATE OF LAST PREVIOUS CHANGE

Courtesy A B Dick Company

FIG 36 5 Route sheet, showing specifications and operation standards

determination, material control, and production control for later jobs When the volume of production justifies the installation, this method of production control, cost collection, and payroll computation offers real economies It is particularly valuable in cost determination for parts, subassemblies, and the finished product Much of the duplicating of orders and forms is performed mechanically

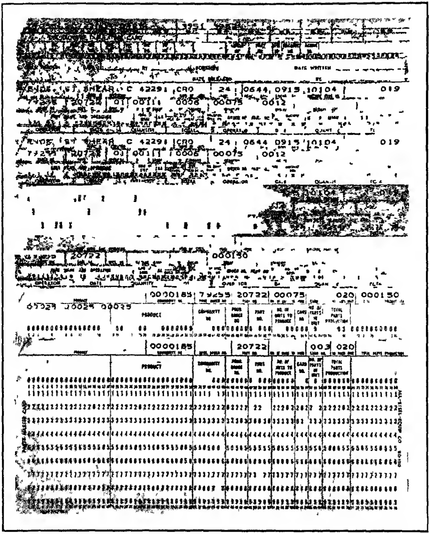
Figure 36 7 shows a composite picture of the various punch cards used by the All-Steel Equipment Company in its control of production This



Courtesy A B Dick Company

Fig 36 6 Mimeograph machine equipped with industrial feed table, roll type feed, knife retainers, industrial hand wheel collating rack, and convenient work surface

company has a set of cards for each product in its line The front card in the assembly, card 1 (the entire face of which is shown), shows the catalogue number, the part number, the card number, and the number of parts in a unit Card 1 is used to transfer a set of these listed items or numbered cards onto card 2 and the order number and the number of units to be produced are then gang-punched into card 2 Card 2 is put in a multiplier and the *number of units to be produced* times the *number of parts in a unit* gives the *total parts to be produced* After all these cards have been made, they are sorted according to part number and run through the tabulator, where a *summary card* is punched showing *order number, part number,* and *total quantity*—card 3 Card 4 is illustrative of the cards for *each part number,* showing each operation to be performed to complete it Figure 36 8 illustrates this card 4 complete Card 5 is the



Courtesy All Steel Equipment Company Aurora

FIG 36 7 Punch cards used in production control

same as card 4 but the *order number* and *quantity* are missing on 4 Card 5 is card 4 after having had the *order number* and the *quantity* gang-punched by using card 3

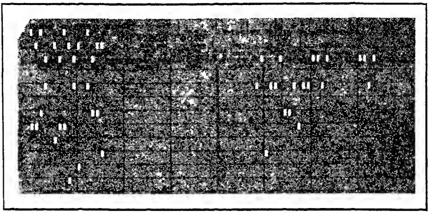
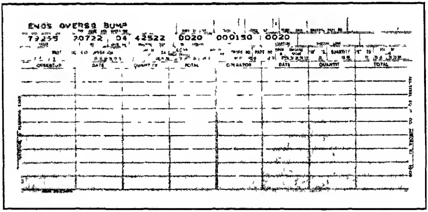


FIG 36 8 Card similar to card 4 from composite Fig 36 7

Card 6 is exactly the same as 5 and is sent to the factory along with 5 Card 5 is given to the employee while 6 is retained by the time clerk as a tally card All of the face of card 6 is shown as Fig 36 9 Cards 7 and 8



Courtesy All Steel Equipment Company Aurora

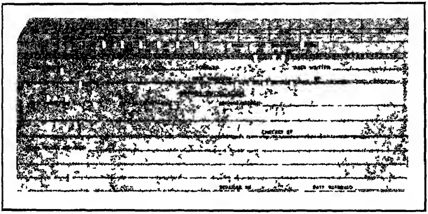
FIG 36 9 Card similar to card 6 from composite Fig 36 7

are identical save for their color One of these cards is sent to the pressroom foreman to indicate the date needed and one is sent to the toolroom so that the dies are ready The toolroom sends the die to the pressroom along

with the die card on the date requested After the die is used, the die and the die card are returned to the toolroom The pressroom foreman indicates on the die card whether or not they have had any trouble with the die (Fig 36 10)

Punch cards can be used for almost any phase of production control, cost data, and material controls Figures 36 11 and 36 12 show several uses of this equipment

Routing two or more items together It may be desirable to have two batches of material routed together for a certain distance through the



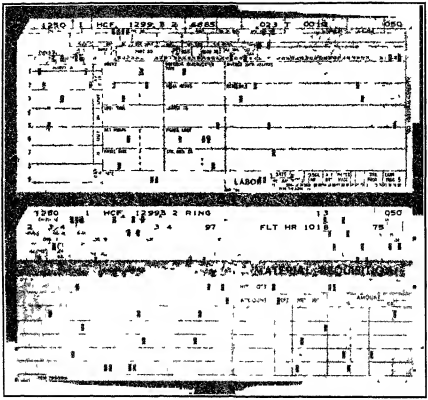
Courtesy All Steel Equipment Company Aurora

FIG 36 10 Die-request card

course of manufacture and then split Or it may be desirable to bring together two or more batches of material at given points in the manufacturing process, although in the main they will follow separate courses Such conditions usually call for combination routing, which provides for the routing of the various batches so that the relation of one to the other will be clearly evident Combination routing is provided for several jobs in production which may use the same setup on any machine In order to save time and setup cost, these jobs are routed in combination

Standard route charts Standard route charts that may serve as a basis for the construction of subsidiary route charts have merit in certain situations They set forth graphically in definite order the operations, materials, machinery, and grades of labor required to make a finished product in the most economical manner and are utilized at times, particularly for new plants or departments They serve as a valuable guide for the installation of the new production-control system and for the instruction of new employees, as a permanent record, and as a guide in drawing up route

sheets for individual orders They are most practicable with standard repetitive products but can be used profitably in any plant where the sequence of operations is similar, although particular operations may vary On such charts the operations are set forth so that their sequence is made

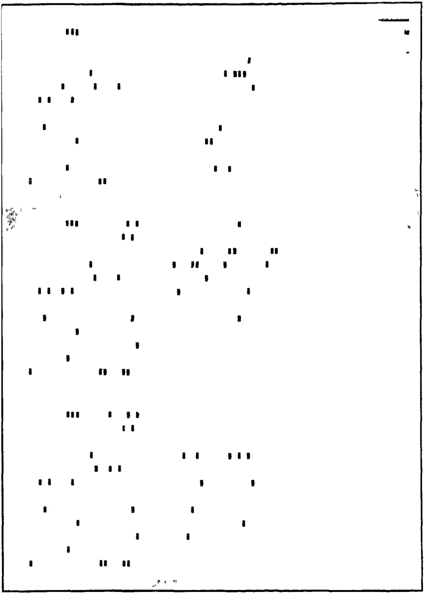


Courtesy Austin Western Company, Aurora

FIG 36 11 Punch cards used for collecting labor data (*top*) and material requisition (*bottom*)

perfectly clear, and, if the product is assembled, the sequence of assembly of the various parts is carefully shown [3] All independent groups of the finished product are so separated that those operations which may be performed independently may be seen at a glance Generally, the following information is included materials needed, with symbols, operations, with numbers, and best machines or equipment for their performance A combination schedule and route chart provides for the charting of all opera-

[3] See Ralph Currier Davis, *Industrial Organization and Management*, Harper, New York, 1940, Chaps 12–15, for an interesting discussion of production control



Courtesy Austin Western Company Aurora

FIG 36 12 Tabulating cards can be used for almost any purpose From the top down are shown master route card, master operation card, and master bill of materials

tions and assemblies in proper sequence upon a scale, which is so computed toward the left from final assembly that reference to the chart will indicate exactly when any component must be placed in production [1] This chart is so devised that the necessary operations upon components and the subassemblies into which they go may be performed in time to have them meet with other components for semifinal or final assembly on schedule Such a chart is extremely valuable if shop conditions permit a smooth flow of work (Fig 36 13)

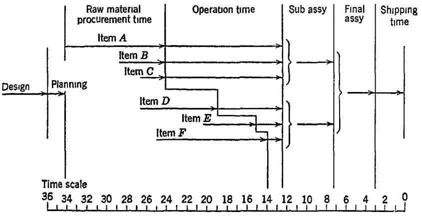


FIG 36 13 Graphic type of master route sheet showing time required for each basic operation

The relationship of routing to scheduling After the original routing is done in mass production, the scheduling and dispatching function is frequently performed by the same person, particularly when activities are divided on a functional basis In routing, an attempt is always made to prevent the utilization of a large, expensive machine for a small job that can be done on a small machine, and yet, if the schedule of work does not provide operations for the large machine and is overcrowding the small one, the route man must take this situation into account in designating the path that material will follow Although he desires always to use the machine that is best fitted for a particular operation, costs may dictate that certain machines be idle while others have jobs waiting It is desirable in routing to observe closely the conditions of the plant schedules to avoid leaving too much leeway in the selection of equipment and too much of the adjustment function to dispatching which is largely a routine clerical job when routing has been carefully and adequately done

[1] L P Alford, *Cost and Production Handbook*, Ronald Press, New York, 1937, pp 245–257 260

37 PRODUCTION CONTROL SCHEDULING

The control of production as to time The most familiar form of schedule control is that of the railroads The processes of industrial scheduling are essentially similar Predetermined schedules control the operations of the offices of railroad dispatchers Similar schedules control the dispatchers of industrial production Factory scheduling involves essentially the same elements There are regularly scheduled orders of varying importance to be taken care of In addition special orders and special conditions must be met as shop conditions change or as the regular schedule is interrupted The plant engineer allocates floor space, the route man prescribes the path of an item through production and the sequence of operations, the schedule clerk allocates time or designates the time factor for specific operations The factors inherent in planning and controlling of production have been clearly expressed by Professor Henry P Dutton as follows

> Before an intelligent plan can be made for the production of an order, at least the following steps must have been taken
>
> 1 The translation of the order into terms of shop requirements This involves editing the order into terms of shop pattern numbers, symbols and so on, also the preparation of parts lists and process analyses
>
> 2 The matching of requirements for materials, machine capacity and other elements against the shop capacity This involves first, the check of parts lists against stock records and second the setting aside of the required hours of productive capacity, after consideration of the reservations already made for other orders Consideration of this stage may involve increases of permanent capacity, when warranted
>
> 3 Scheduling as described above depends upon the securing or possession of knowledge of machine capacities and rates of output and is limited in its precision by the ability to maintain accurately the predicted rates of output [1]

Steps two and three above are primarily concerned with scheduling There are two distinct parts to production scheduling The first, a carefully drawn master schedule which indicates the relative importance of manufacturing orders, may be developed before or concurrently with rout-

[1] Henry P Dutton, Trends in Production Control, an address delivered before the Annual Convention of the Society for the Advancement of Management in New York, October 5, 1939

ing The second is the determination of the order of work, that is, the order in which each job is actually done at every work place This phase of scheduling follows routing in performance and is carried on either before or concurrently with dispatching *The determination of the order of work is primarily a scheduling function, whereas the actual releasing of the orders that start the work in the factory is a dispatching function* Inasmuch as these functions are frequently carried on concurrently by the same person, it is difficult entirely to separate the two in a discussion In so far as they may be separated, the planning function in its elements, rather than in a particular situation, will be clarified

Time relationships in the master schedule The goal toward which management constantly strives is steady, even utilization of productive equipment When a company is operating on a complete budgetary basis, the master schedule is an extension of the budget It is no exaggeration to say that the sales department, when operating within the prescribed company policies, provides the data or raw material from which the master schedule is built Since the annual or quarterly budget cannot give details of customers' orders not as yet received, it is particularly necessary that close cooperation exist between the scheduling division of the production-control department and the sales department in cases in which a plant manufactures both to customers' orders and to stock In the development of a master schedule careful cooperation with the sales department is essential, in order not only that information concerning sales needs from the delivery standpoint may be considered but also that information concerning prospective orders may be secured The man in charge of scheduling has more frequent contacts with the sales department than any other member of the production-control department, especially in a company manufacturing a standard product In large plants the production-control manager may deal more with broad policies than with specific sales orders In such an enterprise the arrangement of the production schedule may be entirely a function of whoever is in direct charge of scheduling production Manifestly, in small plants the production-control manager himself will directly control scheduling

Master schedules and customers' orders Customers' orders in the order of priority usually fall into the following classifications *rush, regular, repair,* and *stock* *Rush orders* include those which are received with necessary delivery dates so stipulated that the product will not be available for shipment on the required date if it follows the regular production routine It requires either special handling or overtime to meet the shipping date This class of orders seemingly never can be completely eliminated Rush orders also include those on which there has been a tie-up somewhere in the production process, so that the order is behind on its pre-

viously determined schedule, particularly when delivery promises have been made in terms of this established schedule *Regular orders* are customers' orders on which delivery dates that fit into the usual requirements of factory production are specified Such orders ordinarily take precedence over repair orders on goods already sold, although *there may be circumstances under which these repair orders will even be placed in the rush class* In some automobile plants repair parts for the service department are manufactured in a separate division for all models other than the one which is currently in production If there are many repair orders, they may be put through on an entirely different manufacturing basis and, in large plants, in different departments from regular orders

Preliminary scheduling requires working backwards from the finished dates set by the master schedule Figure 36 13 shows the lead time in terms of days for each item

Master schedules and production for stock The manufacturing budget forms the basis of the master schedule This carefully drawn estimate of production serves as the basis for the development of the master schedule A plant manufacturing for stock has a flexibility of scheduling that is not possessed by the factory which operates primarily to customers' orders The manufacture of materials for stock implies a close relationship with the policy control of the company In order to schedule a product which has not yet been sold, it is necessary to have a definite knowledge of future sales and production policy The person who actually builds the master schedule may not have all the information but he must have access to someone who has

Producing for stock from a master schedule may be viewed as a replacement program The master schedule provides replacements for the withdrawals that are expected to be made during the period involved Since these withdrawals are greater during certain months than others, the schedule anticipates this unevenness and builds up a reserve in the warehouse to meet any unusual demands When adequate funds and storage space are available, the master schedule may be developed as an aid in stabilizing employment Unless some arrangement is made whereby these schedules may be readily changed, it is very likely that financial difficulties may be encountered because a portion of the working capital is tied up in raw material awaiting processing or in finished products Master schedules are generally based on an expectancy for some such period as 3 months, with actual releases for purchased materials for only 1 month in advance At the end of each month a review of the stock of finished products in the warehouse is made in comparison with the sales for the current month and the reasonably expected sales for the next period The schedule may be continued or revised upward or downward in the light

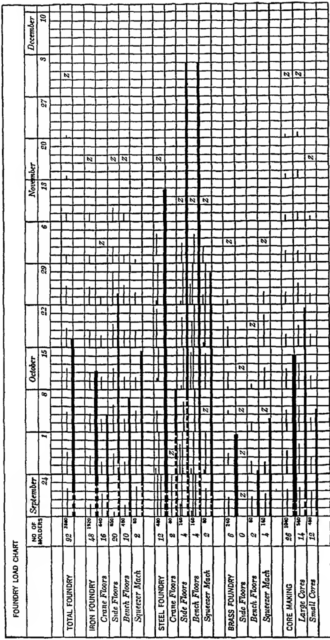
of the monthly review The master schedule should not be looked upon as something rigid into which a new order finds a definite place upon its receipt in the shop, that place never to be changed On the contrary, it should be regarded as a continually flexible piece of shop mechanism, which is modified week by week, perhaps day by day, as conditions change with the receipt of new orders, the completion of old ones, or the development of some new condition in the shop The close liaison necessary between the scheduling function and the balance-of-stores function is evident[2] There must be continual conferences between those in charge of these two assignments

Master schedule and productive capacity By the very nature of the productive process the top productive capacity sets an upper limit on a master schedule On unstandardized diversified products the master schedule may be set up in terms of hours of work ahead on given classes of products Such information, which may be termed the balance of work ahead, can be easily communicated to the sales department If accurate data have been accumulated regarding machine capacities, these data may be used as a basis of the master schedule Machine-tabulation control methods described in Chapter 36 are particularly well adapted to indicate the number of hours of work ahead of machines In making sales, the sales department can deduct the time required for manufacture of the product from the balance and thus can always know the unfilled capacity of the plant which it may sell Such a program involves determining everything, by departments, in terms of the hours of time it takes to produce the product The sales department must be kept constantly informed concerning this situation In a sense the sales department sells departmental time rather than products, and the scheduling work is concerned with time rather than with products

The Gantt chart[3] The Gantt chart (Fig 37 1) has many industrial uses It is especially valuable in production control This chart, which illustrates the scheduled load of a foundry, shows the status of work as of September 19 The first line for total foundry shows that there were 92 men, who, when working a 40-hour week, had 3680 productive hours available The narrow lines indicate the work scheduled for each week, and the heavy line the cumulative total of work ahead of the foundry This chart also shows a breakdown of each of the foundries and the different floors or divisions in each foundry For instance, in the iron foundry there

[2] Because of the close cooperation necessary between the balance-of-stores ledger clerk and the scheduling clerk, it is quite common to find both in the production-control planning department

[3] See Wallace Clark, *The Gantt Chart*, Sir Isaac Pitman and Sons, London, 1942, for an excellent discussion of the use of charts in production control



Courtesy Charles A Koepke Plant Production Control" John Wiley & Sons

FIG 37 1 Gantt chart for a foundry

were 16 moulders, having a total of 640 productive hours, on the crane floors They were behind schedule as shown by the broken heavy line The total amount of work ahead, however, was not excessive, being only about 2½ weeks' work if the men could keep at it without interruptions The moulders in the steel foundry on the side floors were about 2¾ weeks behind schedule The letter *Z* indicates the date beyond which no work was scheduled, yet the heavy line for the moulders on the side floors in

Courtesy Remington Rand

FIG 37 2 **Sched-U-Graph machine load shows the actual situation in the shop**

the steel foundry shows that it would take them 3 weeks beyond their scheduled date to get out their production A glance at this chart tells the schedule man where he needs to work to keep his men busy and also where he is behind schedule

The Gantt charting technique may be used for recording inventories and the progress of any particular item or product through production The charting technique is particularly valuable in emergencies, at the start of a new job, or during rapid expansion Charts are often appreciated by a busy executive who wants a quick picture of his entire operations There are mechanical boards that merely duplicate the Gantt principle (see Fig 37 2) When operations are proceeding smoothly, it is likely that neither the Gantt charts nor the mechanical boards that show the progress of production will be kept up to date Such devices are worthless unless they indicate current conditions Another method of keeping a

record of the hours scheduled ahead of a machine is a simple card type of ledger for each machine or group of similar machines in a work center (see Fig 37 3) It is somewhat simpler than the Gantt chart and is well

MACHINE LOAD CARD LEDGER

Machine or Production Center

Week Ending 1 10 Hours 40 | Week Ending 1 17 Hours 40

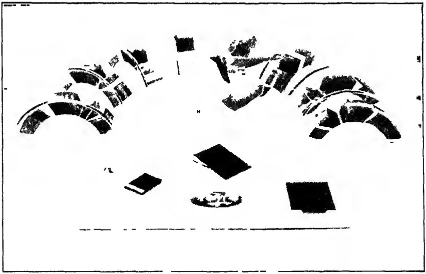
Mfg Order Number	Part Number	Hours for Order	Load Hours Left in Week	Mfg Order Number	Part Number
8092	21	3	37	9341	89
9183	104	30	7		
9341	89	* 7	0		

* 15 Hour job
8 Hours carried over to week ending January 17

Courtesy Charles A Koepke, Plant Production Control John Wiley & Sons

Fig 37 3 Machine load ledger

adapted to a small enterprise Figures 37 4 and 37 5 illustrate another method of keeping production records One of the newest devices that



Courtesy Diebold Inc

Fig 37 4 A Cardineer installation used in scheduling

has great promise for production control and inventory control is the electronic computer and brain The John Plain and Company mail-order house in Chicago is currently using the Remington Rand Distribution, in which thousands of inventory items are kept (Figs 37 6–37 7) The same principle can be applied to machine capacities

Courtesy Remington Rand & Portage Machine Co Akron

Fig 37 5 The Robot-Kardex cabinet holds records used for scheduling, estimating, payroll, cost accounting, and standard time data Each part has a record card All cards for one machine s parts are grouped in a tray stored in the cabinet To bring a tray to the work table, the clerk pushes a coded button

Prescribing the specific order of work The shop does not care who gets the finished product, it wants to know how much is wanted and when the order is needed This information usually is stated on the manufacturing order, and the due date which is placed upon it corresponds to the sequence of the master schedule It is thus clear that the master schedule must be so arranged as to indicate (1) the due date of all orders, (2) groupings of orders into broad classifications of importance, and (3) subdivisions of groups in accordance with particular circumstances, such as the time required to manufacture A single manufacturing order may cover only a portion of the manufacturing budget for a particular article,

or it may combine two or more customers' orders for the same article[4] Thus small customers' orders or large stock orders are increased or subdivided into profitable manufacturing quantities

The master schedule emphasizes bringing the final delivery date to such a point as to coincide with the needs of the sales department The order

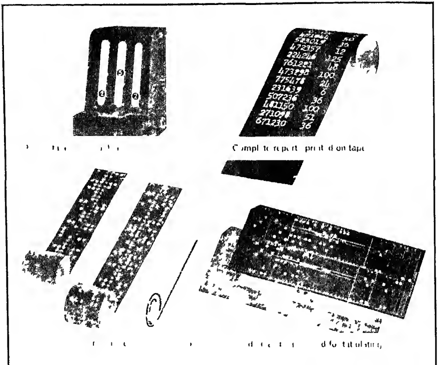
Courtesy John Plain and Company Chicago

Fig 37 6 The Distribution a Remington-Rand mechanical computer and brain The storage drum can list 39,000 items Fantastic speeds and efficiencies have been achieved

of work controls the step-by-step progress of the job through the factory so as to bring the finished product through the process of manufacture in

[4] Some manufacturers, particularly in the clothing industry, release production to the processing departments in quantities measured in terms of the producing capacity of the departments on a time basis, such as 1 hour These releases are known as "blocks" and may be made up of several customers' orders combined to give the hour's work or it may be only a part of one customer's order, depending, of course, on the size of the orders Other manufacturers in mass production release orders in terms of lots which may cover a part of a day's run or several weeks' run of the same part or product All labor and material that can be allocated to the lot is charged to the particular lot number This system ties in well with the cost-control program The releases and schedules of the materials are in terms of the lot

time to meet the needs set down by the master schedule *Changes are but infrequently made in the master schedule, as compared to changes in the order of work* The order of work reflects the ebb and flow of factory conditions If a machine is broken down or a workman is absent, the



Courtesy, John Plain and Company Chicago

FIG 37 7 The Remington Rand Computer can also produce a magnetic record or a punched tape record, as well as printed tape or punched cards for use on tabulating equipment

order of work on another machine or for another workman may be changed in order to meet the needs of the current schedule On the other hand, these small recurring items do not in any way affect the master schedule The routing of a given part or assembly must not be confused with the scheduling of the order in which different work is processed through the shop In determining the order of work the operations must be arranged with consideration of the amount of work which must be done on each and the conditions which exist in the shop, as well as the date when the final work on each order must be completed

The relationship of the scheduling clerk to the foreman In decentralized planning, the foreman often makes out the order for his own department With centralized planning, the foreman comes into contact with the order of work clerk infrequently In centralized planning it is necessary that the foreman be given the responsibility of taking up with the planning department any order of work which he may feel is illogical When dispatchers other than the schedule man are used in centralized production control, the contacts of the foreman are with the dispatcher or the follow-up man It is highly important that this be a cooperative relationship The foreman often can suggest ways of facilitating production at a reduced cost without interfering with delivery dates

Reporting to top management In large-scale industry management can get information for decision-making only through analyzing reports from the divisions The production-control division is in a position through the reports from the schedule clerk to report the "work assigned," and "unappropriated machine loads" as well as

1 A detailed list of all customers orders in process

2 A detailed list of all stock work in process

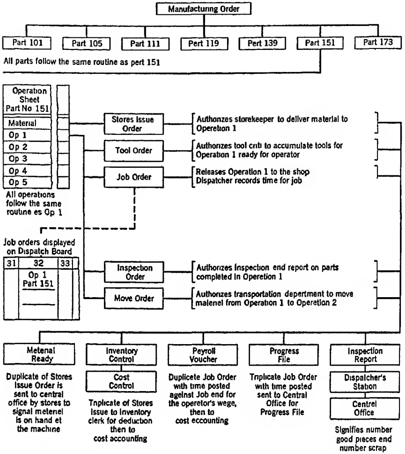
3 A detailed statement of causes of delay or changes in the order of work which have held up production and which may be remedied or improved by executive action

38 · PRODUCTION CONTROL DISPATCHING

Dispatching Figure 38 1 shows the routine in an ordinary dispatcher's office Dispatching includes the execution of all the plans of the routing and scheduling sections of the production-planning and control department It consists largely of transmitting orders to the shop and is carried on concurrently with the operation of the schedule or order of work, but is purely a clerical function Except in large plants the operation of the order of work and dispatching are likely to be carried on by the same individual For clarity of illustration these functions will be discussed as if handled by two persons

An illustration of central production control There are many types and variations of the same kind of central production control Our illustration is a simple one from which certain details may be omitted in practice or to which modifications may be made For instance, there may be no visual planning board but pockets (Fig 39 1) for the orders Our illustration presumes central operation of all phases of planning in a shop in which the nature of the product and orders make necessary complete control of each separate operation The type of jobs and size of lots are varied and are such that the operations are long enough to make this control profitable, yet short enough to allow at least three jobs to be planned ahead of each machine or workman Changes in these basic conditions would necessitate changes in the system This system indicates the factors in production which must in some manner be controlled by the order-of-work clerk and dispatcher The factors which must be controlled include the equipment, raw and worked materials, tools, instructions, inspection, shop transportation, and sometimes the workmen This system clearly controls each of these factors separately and thus clarifies systems which combine control over several factors in production The fundamentals of this system are probably used in many planning departments

Through the operation of the bulletin board (Fig 38 2) or its equivalent, those in charge of the order of work and dispatching have always before them an accurate picture of shop conditions and, through the aid of the route sheets, the status of all orders The illustrative planning-department bulletin board is known as the 3-hook type Pairs of hooks are arranged



Courtesy Charles A Koepke Plant Production Control John Wiley & Sons 1949 p 545

FIG 38 1 Chart showing the routine of the dispatcher's office

in vertical rows in sets of 3 for each machine or work station Each pair of hooks is utilized to indicate the position of work in the shop with respect to that particular machine or work place These hooks are referred to as the first, second, and third hooks, they represent work in the following stages

1 The work which is on the machine
2 The work at the machine ready to be started
3 The jobs ahead in the shop and tentatively assigned to the machine or work place

The lower portion of the board consists of a number of small compartments, one for each work station shown on the board, and other

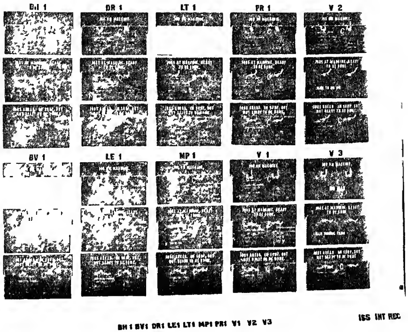


FIG 38 2 Section of planning-department bulletin board

compartments for miscellaneous uses The compartments in the center of the board, which correspond to the machines or work stations which the board controls, are utilized for filing tickets relating to work assigned to the particular machine The 3 compartments to the right are used for temporary filing of tickets that control the issuance of tools, drawings, and instructions The other compartments are used for miscellaneous purposes In each department of the shop there may also be found a bulletin board which displays information concerning work for each machine or work place in the department These departmental bulletin boards may be replicas of the section of the central bulletin board which deals with the department It is set up in the department for the purpose of more readily correlating the activities of the shop foreman and the central planning department and does not imply decentralized planning, although similar bulletin boards are frequently used in the departments when production control is decentralized

The order of work The schedule clerk strives to meet the finished dates established by the master schedule In operating the order of work, he must constantly consult the route sheets, since any determination of the time when an operation is to be performed must rest largely upon the availability of the machines or workmen involved When an order is to be started, he must first consult the route sheets to ascertain whether material is available He can determine this by consulting the check marks which have been placed on the route sheet opposite the heading, "Material Apportioned and on Hand " If he is dealing with an assembly

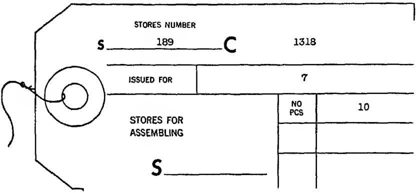


FIG 38 3 Identification tag

operation, he consults the assembly route sheet and there ascertains whether the necessary material has been checked, "O K " All such checks will have been made by the balance-of-stores clerk If material is available, the order or component may be placed in production To start an order in production involves taking from the files certain of the dispatching tickets, which were prepared at the time the order was routed, and starting them through the routines which they affect These tickets include *material requisitions, identification tags,* and *move tickets* The material requisitions have been prepared from the route sheets or bill of materials and filed Before being filed, however, they passed through the hands of the balance-of-stores clerk, who utilized the information on them to increase the apportioned column of the proper balance-of-stores sheets, correspondingly to decrease the available column, and to take such other steps as may be necessary, for instance, to order materials When the order-of-work man removes the stores requisitions from their file, they again pass through the hands of the balance-of-stores clerk, so that he is enabled to write off the material which is being issued from the on hand and applied on orders

columns *The forwarding of requisitions to the storeroom is a function of dispatching* (Fig 38 1) Usually, it is only necessary for the order-of-work clerk to place the requisitions in a designated place, which will indicate to the dispatcher that these slips are to be forwarded to the storeroom and the corresponding orders thereby placed in production

DM 14 IN OUT	C 1318	
PIECE NUMBER	189	
MOVE THIS MATERIAL AS DIRECTED	NUMBER PIECES	10
W________	DRAWING NO	
S	MACHINE NO	91

FROM Stores ________ ON ________ FLOOR

TO 9 ________ ON ________ FLOOR

WORKMAN'S NAME ________ MAN'S NO DM ________

ROUTE SHEETS	PAY SHEET	COST SHEET	I HAVE MOVED THE MATERIALS AS ORDERED ABOVE
			SIGNED ________

Fig 38 4 Move ticket

Identification tags (Fig 38 3) are sent by the dispatcher to the storeroom along with the stores requisition These identification tags are attached to all stores issued and stay with the materials throughout the production process, thus clearly identifying them with the production order on which they are being used The move ticket (Fig 38 4) is then sent by the dispatcher to those in charge of internal shop transportation, as authority to move the material in question from the storeroom to the department and production center where the first operation is to be performed If the route sheet indicates alternate machines on which a given operation

may be done, the writing of the move ticket is at times left to the dispatcher, who selects the machine by consulting the planning board regarding availability Identification tags and move tickets are often combined

The set of check columns on the route sheets used for recording the performance of designated operations now comes into use The columns are headed "Move," "Operation," "First Inspection," and "Final Inspection " A check is made by the dispatching clerk when he orders the performance of any of these functions on any operation indicated as necessary by the route sheet When he issues the move ticket and orders the material from

	OPERATION ORDER	C	1318	
	OPERATION NUMBER		7	
	TO EARN BONUS WORK MUST BE DONE IN	2 48	NO PCS	10
	AMOUNT OF BONUS		DRAW NO	53748
IN OUT	WANTED FOR		MACH NO	91
	HOLD FOR			

FIG 38 5 Operation ticket

stores to the first operation, he may draw a vertical line halfway down the small space under "Move" and opposite the first operation, thus indicating that he has ordered this action When the move has been completed, those in charge of shop transportation return the move ticket to the planning department, noting upon it that the move has been made The dispatching clerk may then transfer this information to the route sheet by completing the vertical check under "Move" and opposite the first operation The route sheet will then show the status of the order at that time, namely, that the material is at the machine ready for the first operation, but that this operation has not yet been performed

As soon as the schedule clerk receives the notice that the material has been delivered to the place to be worked, he establishes the order of work At the time the order was routed, there were placed on the third hooks of each machine or work place affected by the order triplicate copies of an operation ticket (Figs 38 5 and 38 6) This ticket describes and controls the operation to be done on the machine in connection with the order The tickets hanging on the third hooks at any time clearly indicate the balance of work ahead of each machine or department not yet engaged in

production If alternate routing to a group of machines is provided by the route sheet, the operation tickets usually are hung on the third hooks of one machine of the group previously designated When material is moved to a production center, the order-of-work man must remove the proper triplicate set of operation tickets from the third hook and place two of them in proper sequence on the second hook *The position in which he places them on the second hook determines the order of work for that operation on that machine in relation to other operations already scheduled for the machine* He determines the position according to the

DRAWING AND INSTRUCTION CARD ISSUE	DM 3 OPERATION ORDER		C 1318	
OPERATION NUMBER			7	
NUMBER OF INSTRUCTION CARDS		1	NO PCS	10
NUMBER OF TOOL LISTS		1	DRAW NO	53748
ISSUED BY SIGNED	RECALLED BY SIGNED		MACH NO	91

Fig 38 6 Operation ticket Drawing, tool, and instruction issue card

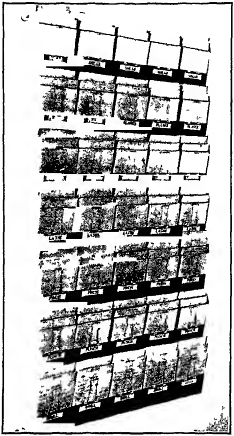
needs of the master schedule The two copies that are placed on the second hook are the planning-department bulletin-board copy, white in color [1] (Fig 38 5), which primarily controls sequence, and the drawing, tool, and instruction card issue copy, pink in color (Fig 38 6) At the same time that these two copies of the operation order are placed upon the second hook, the manila or shop bulletin-board copy is taken to the shop board and placed there

The shop bulletin board may be a 3-hook affair like Fig 38 2 or it may be one of the type (Fig 38 7) which has 2 pockets and a clip, making a total of 3 positions When the dispatcher delivers the work order to the department it will be placed under the clip if pockets 1 and 2 have an order in them Pocket 1 has the order in it that is currently in the machine Pocket 2 has the work order that will be next up on the machine Under the clip will be orders ready to move up in the established sequence

Conditions of a particular shop determine the number of operations for which material should be on hand at any production center, and also the number for which tools, drawings, and instruction cards should be on hand

[1] Any color combinations may be used

Unless the tools are special, they will be used on more than one operation, and it is therefore not wise to have too many waiting at the production points The pink operation ticket controls the issuance of the tools, as well as the drawings and instruction cards The handling of this ticket



Courtesy The McCaskey Register Company Alliance Ohio

Fig 38 7 Machine control board

depends largely upon shop conditions and the number of jobs ahead of particular machines It may not be placed in the second pocket at all, but may be used immediately to order the tools, drawings, and instruction cards to the shop When it is desired that the tools, drawings, and instruction cards be issued, the pink card is put in front in pocket 2 or even under the clip A messenger or the dispatcher collects these periodically and sees that the drawings and instruction cards are delivered to the worker The

tool list is forwarded to the tool crib, where the proper tools are assembled and either sent to the worker or delivered to him when he calls for them on returning the ones he has just used The pink card that specifies the drawings, instruction cards, and tools is then returned to pocket 2 and properly checked, which indicates that this job is ready to go on the machine as soon as it is free from its current work If there are several machines of the same size and type the work may be scheduled to the group and the gang boss may specify the particular machine, depending upon which one is freed from work first

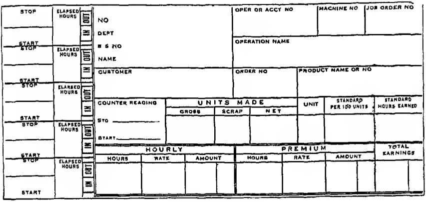


FIG 38 8 Time ticket

Dispatching to the worker When a worker has completed an operation on the job or lot assigned him he brings or sends to the dispatch window of the planning department the time ticket which was issued to him at the same window (Fig 39 1) at the beginning of the operation This time ticket is stamped with the time of receipt, and the workman is ready to receive a new time ticket for his next job The dispatcher consults the bulletin board and ascertains which job is next on the order of work on the second hook of that machine He places this operation ticket on the first hook after removing the operation ticket for the job just completed He then proceeds to the route file, removes the time ticket and inspection ticket (Figs 38 8 and 38 9) for the new operation, hands the time card to the workman, and forwards the inspection ticket to the inspector At the time that the dispatching clerk hands the time ticket to the workman, he draws on the route sheet a half check line under the headings "Operation" and "First Inspection" for the task When the workman brings back his time ticket, indicating that the work has been completed, the dispatcher completes this check line After the inspector makes his first or check inspection, the inspection ticket is returned to the dispatcher, who

completes the check line under "First Inspection" This use of the route sheet as a progress chart clearly illustrates the desirability of having it filed in such a manner as to be readily accessible Upon receipt of the time ticket from the worker at the completion of the operation, the inspection

DM 18 IN OUT	C 1318

FIRST INSPECTION	OPER ATION NUMBER	7

I HAVE INSPECTED THE WORK DONE ON FIRST PIECE AND FIND AS FOLLOWS	NO PCS	10

ROUTE SHEETS	MAN S NO DM	DR NO	53748
	SIGNED BY INSPECTOR	MACH NO	91

FINAL INSPECTION I HAVE INSPECTED THE WORK DONE ON ABOVE OPERATION AND FIND AS FOLLOWS	PIECES DELIVERED TO MACHINE	PIECES LOST AT MACHINE	PIECES DAMAGED EXTRA WORK

PIECES DAMAGED NO EXTRA WORK	PIECES SPOILED AT MACHINE SCRAPPED	PIECES DAMAGED STOCK	PIECES SPOILED STOCK	DEFECTIVE CASTINGS	PIECES O K

ROUTE SHEETS	BONUS RECORD	PAY SHEETS	MAN S COST SHEET	PRODUCTION RECORD	SIGNED BY INSPECTOR

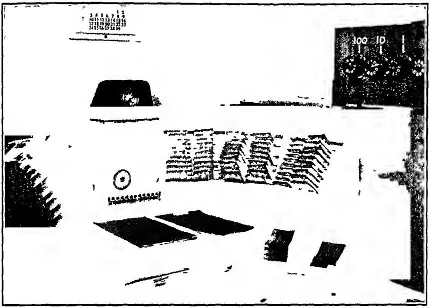
FIG 38 9 Inspection ticket

ticket is reissued to the inspector for recording of the final report concerning quality and number of the lot that is good and can be continued in process, and a half check line is drawn under that column Upon receipt of the final inspection report from the inspector, this line is completed The time and inspection tickets are now forwarded to the rate-setting or cost department for addition of bonuses, deduction of penalties, and general payroll purposes, as well as for entry on the necessary cost records

When the worker finishes his operation the dispatcher or a messenger collects all of the instruction cards, drawings, and tool lists and returns them to the schedule clerk's office The foreman should see that the tools

are returned to the toolroom Often the worker returns them himself before new tools are issued to him

Figure 38 10 shows a unique device developed by Mr Frank R Curtis of Raleigh Ware, Ltd , of Adelaide, Australia The worker steps to an intercommunication instrument and reports his number and the number of the job that he has just completed The clerk stamps the worker's time



Courtesy Factory Management and Maintenance June 1952, p 126

FIG 38 10 Control center The speaker below the clock connects with the departments

ticket completed and enters the number of the next job that the worker tells him he is starting In this manner all time keeping and records are centered in one place In this particular installation the group's efficiency is kept posted in several places in the department by a counter device operated from the dials in the upper right of the pictures A setup similar to this can be used for the departmental dispatcher's station in a large plant or for the plant dispatcher in a small plant

Forms used in dispatching In addition to the forms already mentioned there are punch-card forms covering many phases of work, particularly the time ticket (Fig 36 11) Operation sheets showing incentive-wage standards may easily be combined with a manufacturing order to serve both purposes (Fig 38 11) It at least may readily provide the information

that can be transferred to the individual worker's time sheet The time ticket serves more purposes than any other form used in dispatching It informs the worker of his rate, if this is not on the instruction card It records the length of time consumed in the operation and is, therefore, a basis for all cost computation and wage payment, and it is a vital link in

SHOP ORDER

PAGE 1 OF 1

PART NO	ORDER NO	FOR COMPOSITE NO	DESCRIPTION	PART NO
02943-N	4725	859-NA	Safety Collar	02943-N

DEL. TO RPRS.	PCS. REQ'D	SCHEDULE	ROUGH SIZE	FINISHED SIZE	DRAWING NO
1000	3900	4/28/48	7/8" dia x 1-5/16" long	1-1/8"	

DATE ISSUED	PAGE	M O NO & MACH	MATERIAL SPEC.	CUT FROM	PCS. PER BAR	WGT PER BAR	RGH WT	FIN WT
3/21/48	1	5 C#1620	CRS 1015-20	12-7"	95	25 67	223	

DEPT NO	MACH NO	OPER NO	DESCRIPTION OF OPERATION	TOOLS & EQUIP	RATE PER 100	SET UP RATE	HOURLY PROD	QUAN & DATE CPLT
17	A-13		Rough stock					
35	6205	5	Drill, groove, chamfer & cut off		45	2 25		
TW2		10	Cyanide harden & ctr less grind					
29			Disposition 864-NA (1)NCM baler					
85			Disposition 859-NA (2)NCM baler					

MIN. ECON RUN	ECONOMICAL RUN	MACH LOAD	DRAW SIZE	TYPED BY	DATE	CHECKED BY	DATE	DATE REVISED
				SIS	1/30/48		1/30/48	

Courtesy Charles A Koepke 'Plant Production Control John Wiley & Sons 1949 p 220

FIG 38 11 Operation sheet for incentive wage combined with manufacturing order

the dispatching system The amount of information which must be placed upon it, therefore, is great, particularly in comparison to a ticket, such as the operation ticket, which is used only for control Duplicate copies of time tickets may well replace operation tickets, unless it is felt that the larger amount of information on the time ticket may lead to confusion, or to using too much space on the planning boards The order which is to be charged with the labor represented by the ticket must be indicated, as well as the operation number, which will make possible allocation of costs to operations or departments Provision must be made to indicate the time when the ticket is issued and returned The time when the job

is completed is stamped above the time when it is begun, to permit easy subtraction of elapsed time If an incentive-wage system is used, it is desirable to indicate standard time, the base rate, and the bonus earned on the time ticket

Check spaces on forms A most important part of any form used in control is the series of check spaces provided to insure the performance of all tasks that deal with the information covered by the form Manufacturing orders, time and job tickets, and other forms which are the basis for a procedure involving two or more persons may all have these check spaces provided They not only permit quick placing of responsibility for errors made, but also prevent errors and oversight and insure that, once a procedure is started, all necessary steps in connection with it will be taken

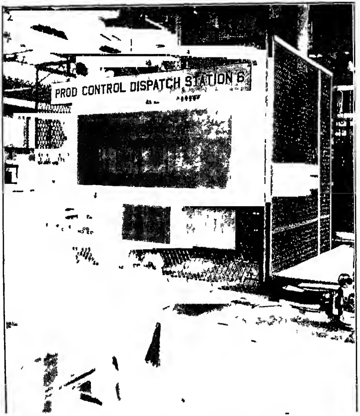
39 PRODUCTION CONTROL IN DIVERSIFIED MANUFACTURING

Ability to adjust to meet changing conditions The purpose of production planning is to control operations in such a way that they will be performed on time and at the lowest cost Care must always be exercised that control schemes do not slow up production If the planning system is so arranged that much time is used by the workman in the exchange of job cards, or if an inordinately large clerical force must be provided to handle the planning procedures, the planning probably has been attempted on too exact a basis and, in the attempt to reach perfection, costs have been unnecessarily increased Planning which is 98 per cent effective is likely to prove more profitable than planning which strives to reach perfection In practical scheduling the planning department makes arrangements to take care of the hold-ups which inevitably occur, and therefore in the long run the control of production operations is smoother

Our detailed discussion in Chapter 37 was not given to be followed without regard to the specific operating conditions in a given department *It is essential that the form be not misunderstood for the essence* These chapters indicate a unified method of handling all the factors of production which must be currently controlled while an order is in process Some companies, instead of using planning boards with hooks, use pockets or boxes for the distribution of tickets controlling operations (see Figs 38 7, 39 1, and 39 2) Many plants utilize a 2-position planning board, rather than a 3-position board, as described In such cases jobs are not posted until an operation is ready to be performed, the operation tickets being retained in the file until that time The rest of the work, instead of being secured from a third position, is obtained from some sort of a load chart It is possible to use a board having only 1 pocket somewhat wider than the illustration in Fig 39 2 In this case the order in front is the one currently in the machine and the one immediately behind it is the next one to go on the machine

Combining forms A combination of the move ticket and the identification card is easily made and simple to use This is especially true when most of the manufacturing is of a standard nature, even though many dif-

ferent products are made Since the route that materials are to take is usually determined when they leave the storeroom, this combining of tickets is logical To run off the single ticket containing the additional information takes only half the time required for the two individual tickets The

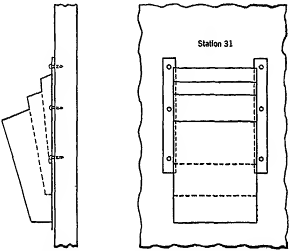


Courtesy, Charles A Koepke, "Plant Production Control," John Wiley & Sons 1949 p 338

FIG 39 1 Production-control station of General Electric Company The large frame on the front of the cage has a layout of the department on it

identification tag may be somewhat enlarged, and on the back may be placed the route through the plant As one operation is completed, the move may be ordered by the inspector who has passed the materials, or, if no inspection is needed at that point in the process, as is often the case, the move man may receive orders to move from the shop foreman In such cases the movement of the material is reported to the planning department at the same time that the inspection report or the job ticket is

handed to it The department has continual knowledge of the location of the material, but it orders the movement from each operation at the time that it first orders the goods from the storeroom If minor changes are needed, they can easily be made on the identification tag by a representative of the planning department when the goods are in process Such a tag is illustrated in Figs 39 3 and 39 4



Courtesy, Charles A Koepke Plant Production Control, John Wiley & Sons

FIG 39 2 Section of a three-pocket dispatch board A two-pocket or a one-pocket board is constructed essentially the same as a three-pocket board

Combining time, inspection, and move ticket Figure 39 5 illustrates the combined time, inspection, and move ticket One way to use such a ticket is to run off one more copy than there are operations These copies may be inserted in a celluloid envelope As each operation is finished, the operator's clock number is filled in, together with the finishing time, the starting time having been filled in as he started The inspector makes his notation and checks the next operation to be performed on the top sheet remaining in the envelope The finished operation ticket is sent to the schedule clerk, and the foreman or inspector tells the trucker to take the material to the next operation The extra copy remains with the work after the last operation is finished (This same technique of running multiple copies can be used when only the time ticket and move ticket are combined) When all the forms for each operation are inserted in the envelope as the work starts, the schedule man does not have quite so close control as when he issues a separate form for each operation, but he can follow the work by checking the ticket sent him after the inspector's count

ASSY OF PART NUMBER	MFG ORDER NO	QUANTITY	LOT NUMBER RANGE	ASSY OR PART NAME	GRADE
1333				Front Shell	Composition

	DATE WANTED	SIZE	CASE NUMBER RANGE	STANDARD FOR 100 PIECES QUANTITY SIZE WEIGHT MATERIAL REQUIRED

STYLE	STAMP NUMBER	SPEC NO	DESIGN NUMBER	DECORATING FINISHING INSTRUCTIONS
		1333/1		

MATERIAL SPECIFICATION SIZE TEMPER

Composition - Soft	3½" Blank
0 021" x 3/8" Wide Coil	3 4 pcs per ft

REVISIONS ENG CHANGE NO AND DATE

DELIVER TO DEPT NO	WHEN	RECEIVED	DATE

Courtesy Illinois Watchcase Company

Fig 39 3 Combination identification and move ticket (*front*)

MOVE TICKET					
OPERATION NO	CLOCK NO	INSP APPROVAL	OPERATION NO	CLOCK NO	INSP APPROVAL
				FORM 619 2 24 46 5M	

FIG 39 4 Combination identification and move ticket (*back*)

This slight loss in detailed control is in no sense of the word serious in a fairly standardized operation By using this combination of forms the planning department need only order performance of an operation, and inspection and movement follow automatically This situation gives the

STANDARD PROCESS TRAVELER

☐ SUB ASSEMBLY ☐ ASSEMBLY ☐ PART

ASSY OF PART NUMBER	MFG ORDER NO	QUANTITY	LOT NUMBER RANGE	ASSY OR PART NAME	GRADE
1294				Back Shell	Sterling Silver

DATE ISSUED	DATE WANTED	SIZE	CASE NUMBER RANGE	STANDARD FOR 100 PIECES QUANTITY SIZE WEIGHT MATERIAL REQUIRED

STYLE	STAMP NUMBER	SPEC NO	DESIGN NUMBER	DECORATING FINISHING INSTRUCTIONS
		1294/6		

MATERIAL SPECIFICATION - SIZE - TEMPER

Sterling Silver – Soft 3 27' Blank

0 021 × 3¼" Wide Coil 3 6 pcs per ft

REVISIONS ENG CHANGE NO AND DATE

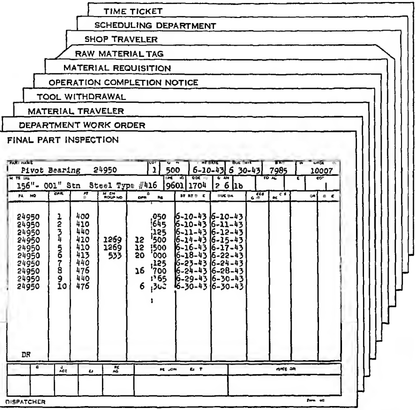
DELIVER TO DEPT NO 33-1 WHEN RECEIVED DATE

DEPT NO	OPER NO	DESCRIPTION OF OPERATION	COMPLETED			INSPECTED			MOVE	
			DATE	OPERATOR		QUANTITY		BY	FROM	TO
				CLOCK NO	COUNT	ACCEPT	REJECT			
82	1	Move from Stores to Dept 33-1								
33-1	1-1	Set Up								
33-1	10	Blank								
33-1	10-1	Set Up								
33-1	20	Joint Offset								
33-1	20-1	Set Up								
33-1	30	Shear Catch								
33-1	30-1	Set Up								
33-1	40	Draw								
33-1	50	Degrease								
33-1	50-1	Set Up								
33-1	60	Finish Strike								
33-1	60-1	Set Up								
33-1	70	Joint Blank								
33-1	70-1	Set Up								
33-1	80	First Curl								

FIG 39 5 Combination time, inspection, and move ticket

foreman somewhat more direction of the production process In such cases proper modifications must be made in the checking of progress on the route sheet and the issuance of new job cards to the worker Time must ordinarily be stamped on the time cards by the foreman or his representative in the shop, and new job cards must be issued on the request of the foreman, as he sees that the worker is nearing the end of a job This change is necessitated by the retention of the time ticket in the shop until after final inspection of the operation

Preparing multiple forms from one master When large quantities of forms and tickets are needed, efficiency can be increased by using multiple reproducing devices Figure 39 6 illustrates several forms that are produced from one stencil As many copies of each form as are desired may



Courtesy A B Dick Company

FIG 39 6 A master form One stencil will run off all the forms used in production control The different forms have the proper headings printed for all permanent data The rest is placed on a stencil that will run as many copies as are needed for one order

be run Each ticket contains the same information, but the ticket may also be drawn so that any additional information may be inserted at the appropriate time as the part moves from place to place In many such operations great ingenuity has reduced the amount of clerical work required in making out production-control forms This type of procedure not only saves time but also contributes to accuracy If the original master copy is correctly prepared, all the other copies will be exact duplicates

	ASST	SIZE	STYLE	OPER NO	QT	AMOUNT
JOAN MILLER LABELS ½ Seams 3/4 U Arm 2 blind hem bottom			9201	30	ODD	[illegible]
Examine trim	[illegible]		9201		UI	265
Turn	[illegible]		9201		U2	030
Mark buttons	[illegible]		9201		MK	0300
Shank buttons on bck	[illegible]		9201		S76	0625
Hem b ttom blind	[illegible]		9201		Q3	0700
P-set sleeves & close sides	[illegible]		9201		P69	1875
Topstitch set zipper	[illegible]		9201		I5	1875
Close side for zipper	[illegible]		9201		I5A	0450
Set yoke to frt Waist	[illegible]		9201		K6	1325
Set Neckline fcgs 30	[illegible]		9201		K2A	1725
WAIST CONT'L			9201	30	ODD	[illegible]
Join shoulders	[illegible]		9201		K2	0425
Pink Piece entire Bck Waist	[illegible]		9201		K2B	1825
Set 1 ops to Waist Bck	[illegible]		9201		K1B	0675
Piece entire frt waist	[illegible]		9201		KI	2225
SKIRT			9201	30	ODD	[illegible]
Join W & S 40' Merrow	[illegible]		9201		I69	0950
Shirr top of skirt	[illegible]		9201		I20	0625
	[illegible]					
YOKE			9201	30	ODD	[illegible]
Merrow edge yoke seam	[illegible]		9201		K69	0375
Off Press yoke	[illegible]		9201		KV1	
Turn fcgs by operator	[illegible]		9201		K4	0550
Piece Yoke fcgs 10	[illegible]		9201		KIA	2875
SLEEVE			9201		ODD	[illegible]
Hem sleeve 20' Blind	[illegible]		9201		H3	0675
Set bottom sleeve dart	[illegible]		9201		H2	1825
	[illegible]					
	[illegible]					
	[illegible]					
FCGS			9201	30	ODD	[illegible]
Piece Neckline fcgs	[illegible]		9201		K3	1625
	[illegible]					
	[illegible]					
	[illegible]					
CRINOLINE			9201	30	ODD	[illegible]
Merrow join Crinoline	[illegible]		9201		HI	0950
	[illegible]					

Courtesy A B Dick Company

FIG 39 7 Strip operation ticket

Strip operating tickets Strip tickets are illustrated in Fig 39 7 This particular type of ticket is often used in the manufacture of men's clothing, shoes, hosiery, and many other items This ticket is assigned a number and attached to the batch of materials as it is about to start through a series of operations It has a coupon for each operation in the series As the worker performs an operation, he detaches a coupon, part of it he usually gives to his supervisor for transmission to the planning department, and part he retains for purposes of checking with his pay envelope This portion of the coupon is necessary for the worker, since there is no direct check with him to insure that he has received credit for his work He receives such credit only as a batch of tickets is turned into the planning department If operations are short and must be performed in the same sequence, this gives all the necessary control for the planning department and at the same time allows the goods to flow through the factory promptly A number of different strip tickets can be provided for the whole sequence of operations, each ticket covering a controllable unit The order of work can be maintained throughout the sequence of operations covered by one ticket, if the numbers on the tickets correspond with the order of work, and if the batch or lot of goods with the lowest serial number is put through each operation first Manifestly, serial numbers can be changed at the end of a series of operations Movement of material at the end of a series of operations must be made on separate order from the planning department, as under any other system If inspection is necessary after operations, it is usually treated as one of the procedures covered by the strip ticket

Control of filling orders in mail-order and wholesale houses The large mail-order houses have pioneered in plant layout and scientific control of filling orders Even the large retail establishments need adequate control of deliveries but they have not been as successful as the mail-order houses in solving their control problems Industrial engineers can make real contributions to increased efficiency in all kinds of merchandising and offices The mail-order houses estimate the volume of work for the day by weighing the incoming mail Definite routes are followed by incoming orders They are first opened by an envelope-slitting machine, they then move on a belt conveyor past readers who remove the contents, count the money, and place it in separate containers to go to the finance division The orders then proceed to other clerks along the conveyor who read them and interpret items that may be confusing These orders also pass by girls who price each item, and others who edit them for filling by the order-filling clerks Copies are typed for each department which may have an item on the order The shipping label is prepared in the central control office All the required information is assembled by the central office

and a group of orders called "blocks" is released at one time These blocks may be of sufficient quantity to require a definite length of time to be filled, such as 20 minutes Naturally the number of employees filling orders and the nature of the orders influence the number of orders in a block All items for a given order, provided they are in stock, meet in the wrapping and shipping department, where they are assembled in one package if possible, weighed, routed as to parcel post, express, or freight, and started on their journeys to their buyers The mail-order houses strive to ship every order within 24 hours after its receipt This policy is adhered to with a high degree of performance

Decentralizing production control The development of the master schedule and the routing between departments are functions which must be performed centrally Even the delivery of finished items from one department to another may be left to the department finishing the item in cases of large-scale production where the producing foreman has the responsibility to see that all finished items are moved at once It is surprising how soon truckers learn to move materials as soon as they are finished when some simple device is used to show them that they are ready to be moved Decentralized planning and dispatching are almost imperative in large plants

Routing to machines is the planning function most frequently left to the planning supervisor of the department If this function is given to him, of necessity much of the operation of the order of work will automatically go with it If there is decentralized control, dispatching to the worker will always be done within the department If routing is to be given to the planning supervisor of the shop, whether he is or is not under the control of the foreman, there are usually certain operations which must be routed centrally An illustration is the situation existing when there are only two or three machines of a given type, yet several departments have work that has to be done on these machines Under such circumstances central routing is desirable to prevent throwing the shop out of balance

Departments having large batteries of the same kind of machines, all capable of doing essentially the same kind of work, provide ideal conditions for decentralized routing because the foreman or the planning supervisor of the shop is ordinarily in a much better position to determine the machine to which a particular job should go than is the central planning department In such cases, the routing of material to the department, nearly always a function centrally performed, is in reality routing to a particular group of machines The decentrally controlled routing takes on the nature of a dispatching function, which will indicate the machine of the group, which, from the standpoint of shop conditions, is best able

to take on the particular operation If routing of this nature is done decentrally, the central route sheets will ordinarily indicate only departments, not machines, and there will be no necessity of maintaining route sheets within the department The planning station in a department of a shop operating under decentralized control may maintain a planning board which is similar in almost every respect, including operation, to the central planning board, save that it covers only the machines and work places of the one department If such boards are maintained departmentally, there is little or no need for the central board, which will be replaced by some sort of progress chart indicating the operations to be performed by departments, and the progress that has been made upon them

There may be at least two clerks in a large department, one working on cost data and the other devoting his time to planning and controlling the production schedule Both these functions are usually performed, even though the volume of work may justify only one clerk If there is only one clerk, he will often report functionally both to the cost department and the planning department, even though he may be directly under the supervision of the department foreman

Under decentralized control, movement of materials between departments may be ordered by the departmental planning unit, but after consultation, usually by telephone, with the central planning force Movement of material from stores to the first department in which work is to be performed may or may not be ordered by the central department If, under decentralized control, work is moved from a manufacturing department to a separate inspection cage, the department planning unit will usually order the work into the inspection cage, while the ordering of the work out of the inspection cage to the next department will frequently be left to the central planning group

Where decentralized planning is followed, control is likewise decentralized Decentralization is only a means of making the control run more smoothly Nominally, the foreman is usually put in charge of the departmental planning under this arrangement Nevertheless, the planning clerk in the department, who is theoretically supposed to report to the foreman, is usually given such complete control of planning by the foreman that he is, to all purposes, wholly a representative of the central planning department in the shop In addition to correlating the work of the department with the central plans, he makes reports of progress on work under way, which enable the central department to post any records of progress which they may maintain

Dispatch stations Dispatch stations in the shop (Fig 39 1) do not imply decentralized control, those in charge merely issue the tickets at the direction of the central planning department Perhaps they have some

control over movements of material At any rate, in large plants they save steps and time for the worker To have the worker come to the window of the planning department for his new time ticket is possible only in small plants In large plants that use central planning it is desirable to locate dispatch stations in the shop or to provide pneumatic tubes through which time tickets may be transmitted Because of the expense of such tubes and the desirability of direct contact between the workman and the man who is handing him his job, the first choice is usually adopted

40 PRODUCTION CONTROL IN MASS-PRODUCTION INDUSTRIES

Mass-production planning and control One of the great advantages of mass production is the high degree of specialization Assembly lines are justified because they can be set up and run for considerable time Special-purpose machines making only one part can be used There are not so many changes in mass production as in a smaller enterprise, hence, the procedures are simpler It should not be inferred that there are no changes in setups in the mass-production plant In fact, the large plant may be conceived as an orderly arrangement of a series of smaller plants known as departments, the respective departments being the suppliers of other departments Some of these departments manufacture parts, but not in quantities to keep the machines constantly in use These machines are changed from time to time Other machines perform only one type of work for as long as 1 year The fundamentals of production planning and control are the same in the small jobbing shop and in the large-scale enterprise In either case materials must be identified and accounted for, operations performed, labor costs accumulated, and inspections made It is in the original development of the manufacturing process and in the layout of the machinery that the greatest problems arise Since the automotive industry has developed this type of production most completely, it has also worked out, to the greatest extent, production methods suited to the process (Fig 40 1)

Production control in the automobile industry Figure 40 1 represents the scheduling and routing of an automobile at the Chrysler Corporation In the eyes of the American people and possibly the world the automobile industry is the symbol of mass production The automobile industry has led the field in plant layout, use of conveyors, flexibility in certain details of a standard product, use of special-purpose mass-production equipment, and the application of Taylor's principle of high wages and low unit costs Other industries, such as farm-implement manufacture, steel manufacture, electrical manufacture, and clothing manufacture, have adapted the mass-production techniques of the automobile industry to the individual requirements of their respective enterprises

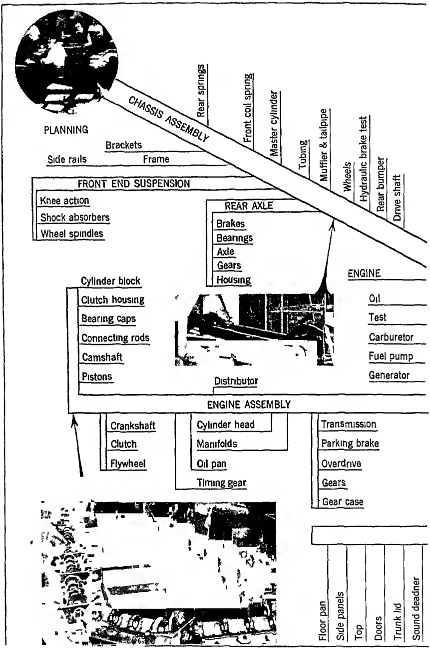
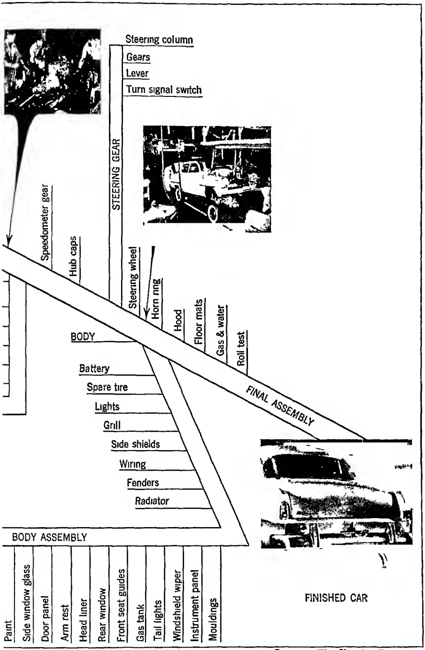


Fig 40 1 Diagram of the automobile



Courtesy, The Chrysler Corporation

assembly line with feeder lines

Some automobile assembly departments have produced more than 2 completed cars a minute To achieve such production careful timing of each of more than 15,800 parts, subassemblies, and raw materials is required Hundreds of freight cars and trucks are unloaded and loaded daily, so that adequate loading and unloading docks, as well as material-

Courtesy Oldsmobile Division General Motors Corporation Lansing

FIG 40 2 Special control panel regulating the conveyor system in the Oldsmobile final assembly plant The upper panel is a reproduction of the principal conveyors in the plant Whenever a conveyor stops in the plant, the indicating light on the panel is illuminated to indicate where the stop has been made Duplicates of the layout and signal lights are located at strategic points throughout the plant Once a conveyor is stopped, the light on the indicating panel cannot be put out unless it is reset by a special key even though the conveyor is started again There are 18 line and 24 feeder conveyors in Oldsmobile's final assembly plant

handling equipment, are needed (see Fig 13 4, p 13 3) Many purchased parts and assemblies go to the assembly line directly from their outside supplier and must meet a time schedule, just as do the parts produced by the plant itself

Figure 40 2 shows the master control board which registers the operation of every conveyor line in the Oldsmobile plant, Lansing, Michigan Signal lights are off when lines are operating normally but a light flashes indicating the location of any stoppage The upper panel is a reproduction of the principal conveyors in the plant Oldsmobile has one of the most complete centrally controlled assembly lines in the United States

The completed automobile is largely an assembly of a series of subassemblies put together in an orderly sequence The frame comes to the final assembly line from another department or even from a plant miles away, as do the body, steering wheel, wheels, fenders, tires, and engine

Courtesy Studebaker Corporation

FIG 40 3 Automobile body is lowered onto the chassis as it moves down the assembly line To get the proper combination of color engine, wheels upholstery, etc requires careful scheduling and production control

As the frame proceeds down the assembly line, brackets are attached, to be followed in turn by the front axle assembly, rear springs, rear shock absorbers, rear axle assembly, including brakes, drive shaft, etc , fuel tank, power plant, steering gear, exhaust line, hand brake, hydraulic brakes, wheel assemblies, including tires, radiator, battery, body (see Fig 40 3), fenders, front end, and running boards, hood, headlights, bumpers, hubcaps, and floor mats Before the end of the assembly line is reached, gasoline is placed in the tank, and the car is driven off the line under its own power Each of these assemblies was started in time to be ready when needed on the assembly line

The entire manufacturing process used in automobile manufacturing represents the *flow type of production* Scheduling is keyed to make this possible Some of the material that goes into the assemblies is produced months ahead of actual use in the final product Orders are anticipated, so that malleable iron parts are cast as long as 30 or even 90 days in advance, gear blanks are machined, upholstery is woven and dyed, tires, tubes, and rims manufactured, etc , so that a dealer's order for a particular model with a specified color and trim combination may be filled in a reasonably short time, usually from 1 to 2 weeks

Scheduling mass-production operations The simplest form of mass-production scheduling is found where production is from a budget for stock In other mass-production industries such as men's clothing the schedules may be made up largely from customers' orders with a few of the relatively stable numbers being made for stock In the automobile industry a master schedule anticipates the sale by types and colors but it is subject to change as manufacturing progresses when customers show a preference for certain models, colors, etc , not anticipated The master schedule in the automobile factory is very simple, merely a sheet of paper showing the number of each type of automobile to be made in a given month or months This master schedule is broken up into components by the production department If 1000 automobiles are to be made in a given month, 1000 crank shafts, but 5000 wheels will be needed Presumably there will be a sufficient amount of each type of equipment in the factory to make the relative numbers of each part that are to be manufactured within the plant The planning department must see that the schedule does not call for larger amounts than the capacity of the equipment or assembly lines can produce If this should happen, the general management must decide whether additional capital is to be invested in equipment to meet the increased load, or whether the emergency is to be met by overtime, an additional shift, or letting out more parts to be made on the outside

Purchases are made largely in terms of the master schedule with releases of shipments on a 10-day or possibly 30-day basis Of course it would be unusual for the purchasing department to place orders at one time for all scheduled production listed on the master schedule for a 12-month period ahead The schedule is broken up according to the time that components and operations on them must be started, in order that assembly lines may have all components as needed Daily quotas for each component are then set, these bearing a direct relation to the master schedule In many plants deliveries are arranged so that only 2 or 3 days' supply of any purchased material or component is on hand at a time Manu-

facturing operations on components are laid out in the same manner This procedure reduces to a minimum the amount of capital tied up in materials, and it also reduces the amount of storage space needed

Lead time for mass production Figure 40 4 illustrates the time required to convert a congressional appropriation into aircraft ready for combat In the automobile industry the time lag is not quite so long,

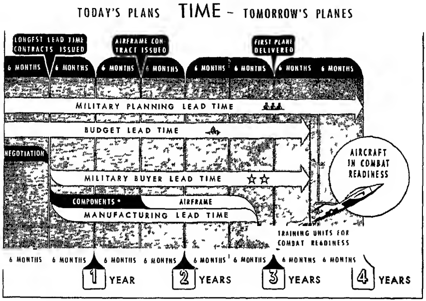


FIG 40 4 Lead time for converting Congressional appropriations into flying aircraft

however, in this industry it is not unusual for 2 years to elapse from the time intensive experimental work is translated into production drawings, machines and tools readied, materials purchased, to the time cars are available to the consumers in quantities In the case of an automobile-body manufacturer changes in the design of the product and in the processing frequently require a revision in manufacturing time or a readjustment in plant layout, and at times result in excess manufacturing space or a need for additional floor space The introduction of the all-steel body has eliminated the woodworking departments, the large dry kilns, and the large lumber storage space The substitution of steel for wood has reduced the length of the production cycle Table 40 1 illustrates the lead time for several basic items going into the automobile body

Table 40 1 Time Distribution Schedule for Automobile-Body Material *

Material	Placing Order with Supplier (days)	Release of Detail Specifications (days)	Delivery to Plant before Use (days)	Processing Time before Assembly (days)
Sheet steel	90	With order	30	10–30 †
Malleable castings	42	With order	10–30 ‡	3
Upholstery	90–120 §	With order	30	10–30 ‖
Lacquer	30	14	7 ‡	0
Glass	60	45	7–10 ‡	0

* This schedule is based on the lowest inventory point considered acceptable

† Fabrication of the steel panels used in the construction of a unisteel turret-top body requires from 10 to 30 days, depending upon transportation facilities and the proximity of the manufacturing and the assembly plants One complete set of stampings demands the use of some 600 major dies, which are rotated in the presses Ten days are required to complete a set of body stampings

‡ The bank of material carried in stock ahead of processing depends largely upon the distance of the source of supply from the plant using the material Lacquer and glass come ready for use and require no lag between the time of receipt and use

§ The variation in time is dependent upon the general situation in the wool market

‖ Preparation of the interior trim for a single body takes from 10 to 30 days of elapsed time The material must be inspected, graded, matched, cut, and sewed

Planned control in shipping It is extremely difficult to give prompt service in deliveries to customers in retailing or even in wholesale houses and be efficient at the same time For instance two separate shoppers from Evanston (18 miles from Chicago) shop in Marshall Field and Company on Thursday morning and afternoon, respectively The articles purchased by each are expected by their purchasers on Friday It is a simple matter to hold all parcels for Evanston that arrive in the delivery department after 4 o'clock for delivery on the second day from the date of arrival There has to be some cutoff point for sorting shipments or else the planning and scheduling of shipments are almost impossible on an orderly and efficient basis Of course, a particular item may be given special handling and get on a truck as it leaves the door Instances are on record where two separate deliveries have been made from the same Chicago store to the same Evanston house on the same day merely because the two items did not reach the shipping floor at a given time and the store was trying to give prompt delivery service Prompt service in shipping is likely to deteriorate into a series of specials unless orderliness and system are insisted on

In the meat-packing industry many dealers are not equipped to handle carload shipments The large packer is faced with two problems that require close control One is that excess labor and equipment will be needed if shipments are not synchronized with a definite schedule The second problem is one of service The dealers want delivery to coincide with their sales needs Increased use of the practice of "mixed car shipments"[1] caused a difficulty to arise at a midwestern meat-packing plant that the management thought could be solved only by increasing its shipping facilities An outside firm of consultants was called in to make a survey The survey revealed that a proper system of scheduling would eliminate the necessity for additional loading stations and would give better service to the customers After more than 15 years of actual service the planned control of shipments is still working satisfactorily, and there has been no further consideration of enlarging the shipping facilities Not only does careful planning and control of shipments reduce costs, but it insures a more reliable delivery of goods even though at times there may be 1 day's delay in delivery This delay in delivery may be avoided by working the sorting and loading crew for an hour or two after the close of regular business, thus enabling the trucks or cars to be ready to move immediately in the morning When this practice is not followed the items delivered late to the shipping floor may not make the shipments on the following day

Control of materials in mass production One of the finest statements that has ever been formulated on the handling of materials in mass production has been made by Professor Charles B Gordy of the University of Michigan, as follows

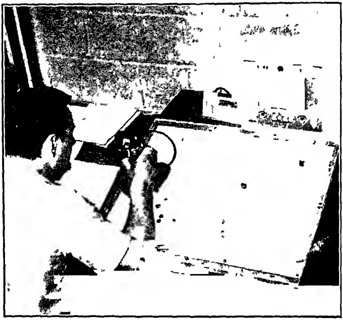
> Stock records can be arranged in a manner that will facilitate greatly the follow up The issuing of a requisition for each batch of material leaving the storeroom results in too much clerical detail, in the case of the larger part of material used in assembling an automobile Material can be charged from the stock records on the basis of the number of cars or units produced during a week or month, by breaking up this amount of production into the component parts of a complete unit Certain companies have gone a step farther, and disburse stock on the basis of the manufacturing schedule in advance of building This gives the follow-up department a knowledge of any shortage existing at the beginning of the month and gives sufficient time in which to expedite deliveries[2]

In so far as practicable a substantial amount of bulk material such as batteries, tires, and wheels, is delivered to an area adjacent to the place these parts are assembled or placed in production The layout of such plants should be so arranged that there need be relatively little finished-

[1] See Fred E Clark and Carrie Patton Clark, *Principles of Marketing*, Macmillan, New York, 1942, pp 438–441

[2] *The Journal of the Society of Automotive Engineers*, Vol 16, No 6, p 607

parts storage The equipment should be balanced so that enough parts will be produced daily for assembly requirements, and these parts should have the last operation performed on them so that they are available immediately for assembly, being finished either adjacent to the point of an assembly line at which they are used or near a conveyor which takes them to that point Of course, this ideal cannot be reached exactly, and it is



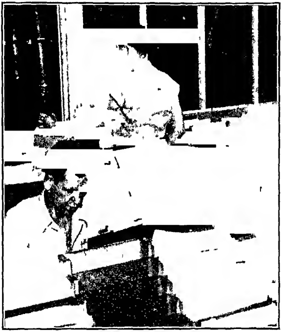
Courtesy General Electric Company, Electronics Division, Syracuse, New York

FIG 40 5 Dispatcher at the Electric Storage Battery Company controlling the movement of materials handling equipment through the use of General Electric two-way radio

often desirable to have some finished parts banked near the point of usage to guard against temporary breakdowns

Delivery dates for incoming materials for a given order may extend over some time, and consequently but little paper work is necessary in handling stores in such plants Follow-up of purchasing is responsible for seeing that materials are delivered in time to meet schedules It will be recalled that the purchasing department is frequently given a copy of the schedule with material requirements If this is not done, the production-control department places requisitions with the purchasing department for the material needed Control of incoming shipments facilitates receiving and locating of the received materials

Functions of the production-control department in mass production In quantity production, production control's functions are mainly to work up the schedules, to tell the various department foremen how many units they will be required to make in a specified time, and to maintain records to insure that the schedules are being followed As in any planning department, time study and material control may not come under the direction of production control It is not necessary, because of direct line layout, to control work between machines to any considerable degree It is obvious that, on account of the similarity of the work put through the plant for a long period of time, the planning department is only breaking down into units the major business budget However, with the advent of many color combinations in the automobile industry, planning—especially the dispatching function—has become immeasurably more complicated, even though the individual assemblies are still relatively simple to control Production control requires less detail in the issuance of move orders and other paper work in mass production than in small-scale diversified manufacturing



Courtesy The Chrysler Corporation

FIG 40 6 Production control office

Figure 40 5 shows a dispatcher directing the material-handling equipment through the use of a two-way radio Figure 40 6 illustrates the functioning of a dispatcher's office and the intricacies of control in an automobile plant Through the teletype (Fig 40 7) and the "track sheet," instructions are given to some 60 key points scattered throughout the plant

Courtesy Studebaker Corporation

Fig 40 7 Teletyped information is sent to key points in the subassembly areas and the assembly line so that the proper combinations roll off of the assembly line to meet customers' requests

For each car built specific instructions regarding color, type of upholstery, and kind of equipment are issued on a track sheet From this track sheet each department interested can tell the exact order in which certain chassis are moving down the assembly line and is thus in a position to load its conveyor with the proper parts to go with each particular car When a body is released to the body-finishing and inspection line, this is a signal to order all other parts to match the body, and instructions are issued accordingly It is seldom indeed that the wrong body-color combination reaches the body drop

The student of manufacturing control must recognize that relatively few types of manufacture can be put on a quantity basis such as that just described This type of production is possible only when manufacturing a

relatively few standard items for which there is a large demand It will be evident that such a system is profitable, not only because direct production costs are lower, but also because the costs of production control, when the volume involved is considered, are much less than in diversified manufacture It must be remembered that large-scale production is possible without the high degree of "flow" type of production used in the conveyorized automobile plants For instance, shoe manufacturing is large-scale, yet there are literally hundreds of sizes and types of shoes Naturally, each industry has to modify its processes of manufacturing and production control to meet its particular needs

PART 9 — PERSONNEL ADMINISTRATION AND MANAGEMENT (INDUSTRIAL RELATIONS)

41 · THE ORGANIZATION AND POLICIES OF THE PERSONNEL DIVISION

The personnel function The personnel function is concerned with all of the human relationships among workers as people and not strictly with the economics of production or selling The harmonious operating of the personnel function contributes in a positive manner to the efficient discharge of the economic function of a business The objective of *personnel management, personnel administration,* or *industrial relations* in an organization is to attain maximum individual development, desirable working relationships between employers and employees and between groups of employees, and effective moulding of human resources as contrasted with physical resources [1] In order that specialized skills may be brought to the solution of personnel problems, the personnel division has been emerging during the past 35 years Many a sound personnel policy formulated by major executives would scarcely be recognized by these executives if they saw its transformation in the process of being passed down the line organization In all discussions of personnel relations it should ever be kept in mind that the *most effective personnel relationships are those which grow naturally out of the work situation,* and that the personnel department's major function is to promote a harmonious environment for the worker The personnel department is that section of an organization that can continuously look at operations from the viewpoint of the worker And, regardless of its own particular method of organization, this is its primary reason for being

The organization of a personnel department does not mean that line executives may cease to think of the workers' point of view It merely means that there is in the organization a department which will now continually bring the workers' point of view to the line executives Neither

[1] This statement of the objective was formulated by a small group of members of the American Management Association during an informal discussion of personnel problems See "The Function and Scope of Personnel Administration," *Personnel,* July, 1947, pp 5–7

does the creation of a personnel department relieve the general management of the necessity of considering major policies with the workers' point of view in mind *No personnel policy will succeed which does not have the original and continuous backing of the general management* The personnel manager should keep the general management in constant touch with the attitudes of the workers and guide management in making decisions which will command the whole-hearted cooperation of the workers The personnel manager strives to create an atmosphere in which all employees can find social as well as economic satisfaction from their work In a very real sense *business is both a way of life and a method of earning a livelihood* This satisfying relationship is not one big item but a continuing series of little as well as big things A primary step in developing the desired positive attitude is to provide for the hearing of any complaints concerning wages, treatment, or conditions, to investigate these complaints, and, if valid, to endeavor immediately to adjust them and prevent their recurrence Although it is fundamental that the personnel department shall thoroughly understand and be sympathetic with the employee, in this relationship they must not forget their obligations to the production forces nor the requirements of production

Organization of the personnel division *Personnel management is management,* not a substitute for management The industrial-relations department is a staff department as far as the entire organizational structure is concerned The various functions of the industrial-relations division may be classified as follows

1 Maintenance of an adequate labor supply (employment)
  1 1 Selection and placement
  1 2 Follow-up of the new employee for initial adjustment
  1 3 Promotion, transfer, and discharge
  1 4 Layoffs, rehiring, and retiring
  1 5 Records and research
2 Education and training
  2 1 Introduction of the worker to the company's policies and to his department supervisor
  2 2 Job instruction apprentice training, vestibule schools, instruction on the jobs, etc
  2 3 Foreman and executive training
  2 4 Special training programs for college graduates and other selected employees
  2 5 Preparation of a special annual report designed to provide information desired by employees
  2 6 General industrial education
  2 7 House organ and library facilities
3 Maintenance of satisfactory personal contacts and employee relationships
  3 1 Job analysis, specifications, and rating
  3 2 Employee ratings
  3 3 Wages and rewards

- 3 4 Shop rules and regulations
- 3 5 Labor audit
- 3 6 Employee records and labor statistics
- 3 7 Regularization of employment
- 3 8 Adjustment of individual grievances
- 3 9 Labor turnover
- 3 10 Suggestion systems

4 Maintenance of satisfactory group relationships
- 4 1 Contacts with employees' representatives
- 4 2 Contacts with employers' groups
- 4 3 Contacts with governmental agencies
- 4 4 Contacts with community agencies

5 Maintenance of employees' health
- 5 1 Initial physical examination and periodic examinations
- 5 2 Treatment for minor injuries and diseases
- 5 3 Hospitalization
- 5 4 Sanitation, health education, and mental hygiene
- 5 5 Rest periods, recreation, and general counsel

6 Maintenance of a safe place to work
- 6 1 Safety guards and inspection of equipment
- 6 2 Safety programs and educational activities
- 6 3 Fire protection and police activities
- 6 4 Safety records and workmen's compensation for injuries

7 Service activities (sometimes erroneously called 'welfare work")
- 7 1 Credit unions and savings and investment plans
- 7 2 Social and recreational activities
- 7 3 Housing programs
- 7 4 Company stores, restaurants, etc
- 7 5 Advisory services, legal aid, hospitalization programs for employees' families, etc

The philosophy of top management and the size of the business enterprise will influence to a great extent the actual physical organization of the industrial-relations division In a small enterprise many of the functions listed above will be combined in the same person In a very small business these functions may be carried on by the plant superintendent secretary, treasurer, chief clerk, or some other person Figure 41 1 shows the organization of industrial relations at the Hawthorne Works of the Western Electric Company, Inc There are three main divisions placement, research, and employee service This chart is so complete that it requires little comment other than to say that this organization is an outstanding leader in personnel research

The personnel function exists in every enterprise regardless of its size and regardless of whether or not there is a separate personnel department Today there is usually a separate personnel department in most companies employing 250 or more persons Although the personnel function exists in any company, it is likely not to be formalized in a company of fewer than 200 people but to be handled by the respective department heads or

INDUSTRIAL RELATIONS MANAGER

1 Assist in the formulation of policies and practices essential to the maintenance of
  1 1 Good relations among employees supervisors and management
  1 2 Good Company and community relations
  1 3 Good relations with other local industries and organizations
2 Maintain and administer an organization adequate to insure uniform and consistent application of these policies and practice
3 Represent the Hawthorne Works in the areas of industrial and public relations
4 Chairman Hawthorne Area Committee
  4 1 Administration of Employees Pensions Disability Benefits and Death Benefits

PERSONNEL SERVICE

Employment Personnel Placement Personnel Results and College Relations

Employment

1 To build up and maintain an adequate working force
  1 1 Recruit applicants through present and former employees advertising outside contacts etc
  1 2 Interview all applicants select those suitable as needed
  1 3 As an aid in selection and selective placement administer employment tests i e tests of intelligence aptitudes abilities interests etc.
  1 4 Conduct exit interviews to obtain employee reactions to the job supervision working conditions Company policies etc Where appropriate endeavor to work out adjustments for the purpose of saving an employee to the Company
2 To answer all inquiries by correspondence telephone etc pertaining to employment possibilities and policies and concerning present or former employees
3 To render clerical services in connection with such activities as hiring and leaving maintenance of employee records education and past work inquiries computation of Company service data on former employees statistical data distribution of service certificates and establishment of vacation eligibility
4 To make a periodic reevaluation of hiring and selection procedures For example developmental and research work studies in the field of employment interviews testing procedures and labor market
5 To conduct all interviews and handle all employment contacts in such a way as to maintain good relations with other industries and organizations in the community

Personnel Placement

1 To assist the supervisor in placing each employee on the kind of work for which he is best qualified and where he will have an opportunity to progress—
  1 1 When he is deserving of advancement
  1 2 When he might have ability and interest of value in new or other work
  1 3 When because of physical restrictions it is no longer advisable for the employee to remain on his present job
2 To maintain essential and current information on employees for upgrading and transferring
3 To serve as a centralized control unit in approving all transfers within and into departments
4 To service the supervisor with information relative to personnel policies and practices thus maintaining uniformity

College Relations Activities

1 Recruit on college campuses
2. Assist Contact Representatives in correspondence reviewing qualifications of recruits arranging visits to Works for interviews and allocated work

Personnel Development Results and Records

1 To issue control reports on personnel subjects for use of management and the Personnel Placement Department
2 To conduct special surveys and statistical studies for the improvement of personnel methods
3 To develop forms and supervise the rating of employees and to make statistical evaluations and interpretations of the results
4 To conduct research in employee relations
5 Act as liaison between the Company and the Blue Cross Plan for Hospital Care
6 To maintain personnel records for all employees in the Hawthorne Works Organization

Restaurant

1 To provide wholesome food reasonably priced at Works locations where commercial restaurants are inadequate
2 To provide special service as indicated by the Medical Organization for employees who for health reasons require special types of food

HOSPITAL AND MEDICAL

Medical and Health Service

1 To determine if people are physically suited for work in industry To consider each person s physical qualifications and conditions
3 To take care of people within certain limits, when they become sick or injured on the job
4 To not expect an employee who is genuinely sick and thus temporarily incapacitated to be on the job
5 To pay for time not worked due to sickness within certain limits
6 To do everything possible to get employees back to work as soon as possible
7 To do everything that is practical and possible to promote good health among our employees

Benefit Safety and Employees Service

Benefit Service

1 To carry out the provisions of the Company s Plan for Employees Pensions Disability Benefits and Death Benefits
  1 1 To prepare Personal and Disability Leaves of Absence for employees
  1 2 To arrange for payment due to sickness death or pension as covered under the Plan
  1 3 Arrange for supplemental pensions to retired employees in deserving cases
  1 4 To report the activities to and secure the approval of a local committee on all benefit matters
  1 5 To prepare for final approval of the Employees Benefit Committee headquarters all cases and matters falling under the Plan

Safety

1 To coordinate safety matters between line supervisors and functional organizations
2 To investigate industrial injury cases to determine cause of injury
3 To coordinate and/or carry on safety training and promotional programs
4 *To compile and interpret statistics (injury experience)* and to issue reports on these data
5 To obtain and distribute personal protective equipment
6 To serve as a contact on safety matters with other industrial concerns government bureaus and professional organizations such as American Society of Safety Engineers National Safety Council and other local Safety Councils
7 To keep informed of current developments in safety promotional activities

Employees Service

1 Assist employees in certain personal financial matters
2 Real estate service
  2 1 To acquire home properties and dispose of leases of homes of employees transferred to other locations at the Company s request
  2 2 To carry and maintain such properties and leases until disposed of
  2 3 To sell or rent such properties held
3 Military Service
The Military Service Organization was set up to supplement rather than to replace the activities of the regular organizations which are functional in reinstating employees Its primary functions are
  1 Handle selective service problems.
    a Registration
    b Deferments
  2 Process military leaves of absence
  3 Assist returning veterans in re employment and other adjustments
  4 Assist veterans *in obtaining hospitalization in government* hospitals
  5 Render advice on National Service Life Insurance

FIG 41 1 Personnel functions of

WORKS MANAGER

LABOR RELATIONS MANAGER

1 Represent the Company in all relationships with labor unions and governmental agencies responsible for administering matters relating to the Company's dealings with unions
2 Negotiate and interpret labor contracts
3 Keep management representatives informed of national and local labor trends

Labor Relations

1 To coordinate relationships between unions and the company
2 To assist in the negotiation of labor contracts and the interpretation of such contracts to management representatives
3 To assist management representatives in the preparation of records of collective bargaining and grievances
4 To maintain, distribute and have available for management use all records of collective bargaining and grievances
5 To gather information and maintain a library relative to national and local labor relation laws, regulations and trends

INDUSTRIAL RELATIONS

Public Relations

1 To maintain favorable public opinion
 1 1 To sustain a proper labor market
 1 2 To create employee pride in the Company
 1 3 To build public favor toward the business and its products
 1 4 To insure that the Company assumes full share of community responsibility
2 To perform liaison between Company and civic, governmental and community groups
3 To handle all public statements to the press
4 To handle all inquiries relative to Company policies and practices from other business, association, etc.
5 To be responsible for all brochures, bulletins, employee publications, and display and classified advertising

Personnel Counseling and Training

Personnel Counseling

1 To make the Company's personnel counseling service available to all employees
2 To conduct initial and follow up interviews with employees on an individual, voluntary, and confidential basis
3 To select, train, and supervise personnel counselors in the skillful introduction and application of the nondirective counseling method
4 To conduct interviews to the end that employees will benefit directly through acquiring a more adequate understanding of and a more effective orientation to their individual situations and to the end that the Company will benefit through the maintenance of worker morale and effectiveness
5 To conduct research in the areas related to the development of counseling work

Training

1 To conduct formal training courses—
 1 1 For such skilled machine trades as toolmaking, die making and machine construction and repair
 1 2 For such plant trades as electricians, pipe fitters, millwrights, and sheet metal workers
 1 3 For production machine operators such as punch press, screw machine, and drill press operators
 1 4 In telephone systems, apparatus, and equipment for technical workers such as engineers, inspectors, supervisors, and others
 1 5 In common office occupations, calculating machine operation, typing, stenographic and secretarial, as threshold preparation for newly hired, transferred or upgraded personnel
 1 6 For operators and inspectors in skilled and semiskilled work such as adjusting of all types of telephone apparatus
2 To organize and conduct general supervisory development program. Recommend and conduct specific training for newly appointed supervisors. Advise and assist local units in giving supervisors training for particular needs. Conduct induction Program for New Employees
3 To assist and collaborate with the line organizations in the development of job training programs and analyses of training difficulties
4 To conduct experiments from time to time in shop operations of a semiskilled or skilled nature to determine the most effective methods of training

Employees Suggestion System and Defense

Suggestion System

1 To acknowledge receipt of all suggestions
2 To maintain records
3 To route suggestions to functional organizations for investigation and reply
4 To approve replies
5 To determine amount of cash awards for adopted suggestions and issue certificates of merit
6 To follow interested organizations to insure that adopted suggestions are put into operation

Defense Coordination

1 Inaugurate and assist in directing the activities required by the Company's program for the protection of personnel
 1 1 Provide central control point from which activities can be directed at time of disaster
 1 2 Provide effective alarm system, protective areas, and train personnel

The Hawthorne Club

1 The Hawthorne Club is comprised of all Hawthorne Works employees
2 All Club policies and activities are developed and administered by and for the employees
3 Some 30 athletic, social, educational, and other activities are sponsored by the Club
4 Club and Company activities and policies are coordinated through the Superintendent of Industrial Relations

Other Employee Activities

The Superintendent of Industrial Relations also acts as the Company contact with other organizations including
 1 An employee savings and loan association
 2 An employee credit union
 3 A life insurance counseling service

NOTE Industrial and Labor Relations activities are but two of the several administrative functions of the Works Manager

Western Electric, Hawthorne Plant

some other person in connection with his other duties Recent trends in labor legislation have added to the work that must be done by some agency of the business In smaller organizations this burden may well be assumed by the personnel officer, thus justifying the employment of a full-time man in an enterprise that otherwise might believe his services an unnecessary expense

Personnel policies Personnel policies, like business policies in general, are dynamic, changing to meet the current situation Although they are dynamic to meet fundamental changes, they nevertheless should possess a large measure of stability The sound personnel policy avoids opportunism and is essentially stable, having due regard for the human equation A successful business enterprise possesses organic unity of purpose A defect in any function weakens the entire organization The objectives of an enterprise are naturally influenced by many considerations competition, tradition in the particular industry, technological development, social approval, the prevailing attitude of labor, governmental controls, and the ideals of the entrepreneurs In the light of our present business mores a sound personnel policy should, in general, possess the following characteristics

1 It should give due regard to the interests of all persons the workers, the consumers, the public and the owners of the capital

2 It should be an integrated part of other basic company policies The lack of organic unity results in confusion

3 It should be definite Ambiguity and uncertainty are destructive of plant morale

4 It should be stable yet possess sufficient flexibility to meet changing conditions and the varying needs of individuals

5 It should provide adequate means for becoming generally known and understood by all persons concerned

6 It should recognize the current trend toward group action and a tendency to seek a voice in those phases of management in which the worker is vitally interested (Management should not be blinded by collective bargaining to the fact that individual differences are important A worker or a group of workers may feel as lost in a large union as if they had no formal recognition whatever)

7 It should recognize individual differences in capacities, interests, ambitions, emotional reactions, and the desire for security

The nature and the extent of personnel policies vary with the individual enterprise Some activities are basically of a personnel nature and yet for organization reasons are not classified under the personnel department There is usually a personnel policy, either in writing or informally understood, covering every item listed under the tabulation of functions of the industrial-relations division [2]

[2] See Scott, Clothier, and Spriegel, *Personnel Management*, McGraw-Hill New York, 1954 p 23, for a detailed tabulation of the activities and functions of a personnel division

Acquainting employees with company personnel policies When the organization is relatively small, the personnel policies can be readily communicated in person or by the use of the bulletin board The actual practices and acquired rights of interested parties become accepted customs and later traditions Even under these simple conditions the problem of initiating new employees into the organization remains difficult With the growth in the size of organizations the problem of mutual understanding of personnel policies becomes increasingly greater To facilitate the transmission of personnel policies to interested persons, to avoid misinterpretations so far as possible, and to lend increased stability to these policies, many corporations publish an employee handbook For the past 20 years this practice has been gaining in acceptance A few of the many outstanding companies that have published statements of their personnel policies are the General Motors Corporation, the American Rolling Mill Company, Eastman Kodak Company, the Procter and Gamble Company, Marshall Field and Company, and the International Harvester Corporation

A business is a social as well as an economic institution The type of work within the plant and within the community which has the greatest possibilities for the development of industrial good will has also the greatest possibilities of paternalism if not founded. upon a sound economic, sociological, and psychological basis The employer must ever be on the alert to avoid acts of normal human sympathy which will later react unfortunately The same end can usually be attained, although possibly with less dispatch, by working through the employees rather than by direct action on the part of the employer Some plants, located in communities which are unable to provide amusement for their citizens because of their smallness or remoteness, occasionally find it necessary to provide living and recreational facilities for their employees in a manner which may smack of paternalism This practice may not prove pernicious, provided it is properly handled What must be avoided are plans indicating that the company feels it controls the entire life of the worker, merely because it is his employer

Usually the "boss" is the management, so far as the individual worker is concerned The company as a group of persons working toward an objective of producing a given product is in a very real sense a vital social as well as economic organization The effective unit is usually the departmental organization so far as social influence is concerned There is both an official and an unofficial organization The official organization is represented by the managerial controls, whereas the unofficial organization consists of the voluntary social structures that naturally take shape when groups of people are thrown into intimate contact with each other

The personal satisfactions derived from membership in the business group are determined in part by the degree of homogeneity of its membership. Not infrequently there may be several groups within a department, based somewhat upon race, religion, fraternal affiliations, age, and sex. Unless the social prejudices are too strong, the social group will cut across many barriers to draw individuals with like tendencies together. It is very common indeed, particularly among people of the same general age group, to find the social lives of the members of a work group intimately interwoven. This is especially true in the smaller cities, but the same tendency exists in the city of Chicago.[3] The company, in the sense of those collectively employed under a given management, bulks large in the lives of the employees, who use the term "we" when speaking of their activities. Business is in a very real sense a social as well as an economic institution. Under proper leadership workmen may readily come to work in the morning "with joy in their hearts and a tune on their lips."

The ratio of personnel workers to other employees. It is impossible to give a ratio of personnel workers to other employees unless the functions coming under the personnel department are clearly defined. For instance, one company includes the safety and sanitation division, the cafeteria, plant protection and watch service, medical service and first aid, job evaluation and wage administration, and payroll departments in the personnel division along with the other activities that are normally included. Medical service and first aid logically belong in the personnel division, but they are found at times as a separate department reporting to a major executive. Even when the same activities are carried on in two personnel departments, the ratio of personnel workers to other employees is not necessarily the same in both for the simple reason that in one plant the program may be more extensive or more employee cooperation may be used. An elaborate recreational program may be entirely in the hands of the employees in one plant and largely company-sponsored in another. In one plant the medical program may be limited to an initial physical examination and first aid, whereas in a second plant periodic examinations, X-rays, and a complete medical program are conducted.[4]

[3] See R. J. Roethlisberger and William J. Dickson, *Management and the Worker*, Harvard University Press, Cambridge, 1940, for a comprehensive study of the social structure of the work group and the influence of morale upon productivity.

[4] See National Industrial Conference Board Incorporated, "Organization of Personnel Administration," *Studies in Personnel Policy*, No. 73, New York, 1946, p. 86; see also Dale Yoder and Lenore N. Wilson, "Employment-Relations Functions and Budgets," *Personnel*, Nov., 1952, pp. 218–226, also July, 1954, pp. 5–9.

42 THE ORGANIZATION AND FUNCTION OF THE EMPLOYMENT DEPARTMENT

The function of the employment department The employment department was the first department of the *personnel division* created in most companies Even today in a substantial number of companies the entire personnel division consists of the employment department The prime function of the employment department is to maintain an adequate supply of qualified workers The following functions are usually the responsibility of the employment department

1 Maintain an adequate source of supply of qualified workers
2 Secure information regarding prevailing community rates
3 Develop job specifications
4 Actually select new employees through
   4 1 The application blank
   4 2 The interview
   4 3 Tests
   4 4 Physical examinations
   4 5 The checking of references, records, and the approval of supervisors
5 Introduce the worker to the company's policies, to his department supervisor, and to fellow employees
6 Follow up the new employee for initial adjustment
7 Maintain records of all employees hired, resigned, transferred, laid off, or discharged

Centralization of the hiring of all employees with the possible exception of executives and supervisors can be justified on the following grounds

1 The supervisor's experience and the time that he is able to devote to hiring men are not usually sufficient to make him expert in the selection of workers

2 The supervisor cannot be expected to develop outside contacts for sources of labor in a way that a centralized department can

3 Individual supervisors are not in a position to see the needs of the plant as a whole, and thus the centralized department is better able to achieve the uniformity in selection which makes for a generally high character of personnel and *esprit de corps,* to place an applicant in the department for which he is best suited, to arrange in merited cases for a transfer of workers, and to prevent undesirable former employees from being rehired

4 Specialization in the employment function is merely an extension of the principles of scientific management to one phase of personnel management

Qualifications of the employment personnel The employment manager should be able to gain the confidence, sympathy, and appreciation not only of the rank-and-file employees but also of the heads of departments He ought to keep his eye on long-run policies rather than on individual cases in which he may differ from the department head Under this policy, with the development of a well-run employment office, the number of selections made by the employment department but rejected in the operating department will be very small To promote soundness of selection, it is essential that the employment manager, his assistant, or whoever interviews applicants shall have a first-hand knowledge of the requirements of jobs Thus, an interviewer of applicants for workers in the shop should have shop experience, even if it was acquired as a special student in preparation for his work in the employment office It is, of course, essential that the interviewer be especially qualified in the *power of analysis* and in knowledge of *human nature,* and that he possess a *constructive imagination* In other words the employment manager should possess all the leadership characteristics of any executive plus the specialized requirements of his position

Source of new employees [1] The sources of the labor supply may be classified under two general headings, *those within the organization* and *those outside,* as follows

1 From within the organization
  1 1 Transfer
  1 2 Promotion
  1 3 Recommendations of friends and relatives by satisfied employees
  1 4 Former employees who were in good standing when they left
2 From outside sources
  2 1 Direct application in person or by mail
  2 2 Employment agencies
    2 21 Union agencies (where there is a union)
    2 22 Government-sponsored agencies
    2 23 Private agencies
    2 24 Religious and fraternal agencies
    2 25 Employers' groups
  2 3 Other business exchanges
    2 31 Reciprocal agreements with certain employers to supply men
    2 32 Agreements as to layoff and discharge
  2 4 Contacts in other localities
    2 41 Labor-department reports
    2 42 Newspaper advertisements
    2 43 Trade associations
    2 44 Governmental employment offices

[1] See W D Scott, R B Clothier, and W R Spriegel, *Personnel Management,* McGraw-Hill, New York, 1954, Chap 5

- 2.5 Educational institutions
  - 2.51 Public schools
  - 2.52 Trade schools, both public and private
  - 2.53 Colleges
  - 2.54 Training schools of manufacturers of special equipment
- 2.6 Advertising
  - 2.61 Newspapers and trade journals
  - 2.62 Radio, posters, billboards, etc.

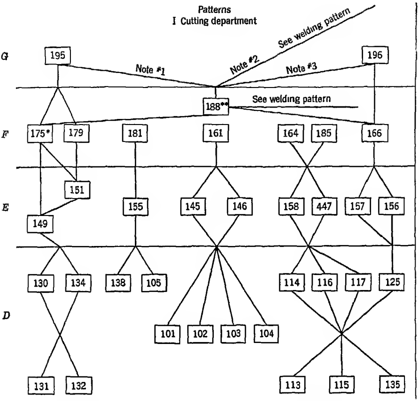
Advertising as a rule is of questionable value save for persons of special skills or training. It is usually resorted to only when there is a labor shortage and results in taking workers from another employer, who reciprocates in kind, with little if any social or economic advantage. A large portion of new workers are usually selected from those who apply at the office. Applications by mail are frequently received, and they form a satisfactory source, particularly for firms with good employment reputations, who are likely to attract workers already employed. Of course, follow-up interviews are necessary before selection, regardless of the amount of correspondence. Workers already employed by the company are likely to recommend others for consideration. These recommendations may easily prove one of the best sources of supply, since workers know plant conditions and are not likely to make recommendations unless they believe that these others will also be satisfied. In times of job scarcity, however, this practice may become a problem, since friends of the workers who are not worthy may exert pressure for recommendations for employment. It is an excellent idea to give the worker a card for his friend which serves only as an introduction with the understanding that he will have to meet the company requirements to be employed. Some private employment agencies go about their work in a professional manner and will recommend only persons who they feel confident will fill the opening. In every large community, however, there are many agencies which come just within the letter of the state law governing their operation and which are not good contacts for the employment department. Public employment agencies are now found in nearly all communities. During the past 10 years the public state-operated employment agencies have improved greatly in efficiency. In some instances trade organizations are valuable aids. In some industries where collective bargaining has been established, particularly in the clothing industry, joint offices have been provided as an aid to the plant-employment managers. Schools, colleges, and speciality concerns who train workers in business practice, such as filing-device distributors, all form valuable contacts. Frequently close relationships can be built up with technical high schools that will yield a very satisfactory source of supply for new employees. Candidates for future executive positions are found more and more among graduates of colleges, and many such

institutions have placement offices which aid the employment manager in getting in touch with their students, as well as with graduates who have been in the industrial world for some years

The job specification The employment office usually hires new employees only at the request of the operating departments These requisitions may be developed in conference at the time that some production or expansion program is decided upon, or they may take the form of routine requisitions made out on specified forms and submitted by the departmental heads from time to time as necessity dictates The requisition should reach the employment department as far in advance of requirements as is practicable In a large company it is difficult for the employment interviewer to be intimately acquainted with the detailed requirements of each job In smaller organizations, it is possible for the employment department to have a more complete and accurate knowledge of the jobs than anything likely to be developed on paper Much information for job specifications can be secured from the methods department or whoever has control of the making of job studies The employment manager should be familiar with the job descriptions used by the methods department In formulating job specifications for his purposes, however, the employment interviewer frequently needs some information of another kind and must also translate for his purposes much of the data on the job-study observation sheets Job specifications should not be too elaborate The job specification of the personnel department is not so detailed as that used by the methods engineer

The job specification should include only those qualities and abilities that will aid the employment officer in selecting the right person for the particular job - Particularly when business conditions are good, it is impracticable to try to fit workers too closely to the job at hand Even the most routine job, whether in the office, in the service department, or in manufacturing, is often transformed by the person who holds it Although this statement does not mean that every attempt should not be made by the employment department to find workers who approximate the ideal for a given task, it does mean that *a new employee should be first of all an organization person,* with some chance of fitting in with the group in the department in which he will work, and, *secondly, should have general qualification for performing a certain type of task, rather than be theoretically a perfect specimen to fit the particular niche that is vacant* Business is dynamic, not static, and, if the employee fits one small niche

- See Scott, Clothier, and Spriegel, *Personnel Management,* McGraw-Hill, New York, 1954, Chap 11, "Job Evaluation and Rating," for a definition of terms The job specification refers to the requirements sought in the worker, and the job description covers the job itself



Job Titles

G	196	Forge Press Operator
	195	Torch Cutter 1C
F	188	Quality Cutting Control Inspector
	185	Bertsch Rolls Operator
	181	Blade Cutter
	179	Box Beam and Channel Cutter
	175	Camograph Operator, 3 Torch and 4 Torch
	166	Press Operator 1C
	164	Brake Operator Large and Small
	161	Plate Shear Operator 1C
E	447	Flash Welder Operator
	158	Rolls Operator Small Buffalo
	157	Press Operator, 2C
	156	Forge Press Helper
	155	Hacksaw Operator 1C
	151	Torch Cutter 2C
	149	Camograph Operator 2 Torch
	146	Plate Shear Operator 2C
	145	Bar Shear Operator Large

Job Titles

D	138	Hacksaw Operator 2C
	135	Blade Cutting Helper
	134	Torch Cutter, 3C
	132	Tracing Template Maker
	131	Camograph Helper
	130	Camograph Operator, 1 Torch
	125	Press Helper
	117	Blade Drill Operator
	116	Double End Punch Operator
	115	Shim and Brake Band Puncher
	114	Punch Operator Blade
	113	Press Operator 3C
	105	Steel Analysis Painter
	104	Plate Shear Helper
	103	Bar Shear Helper
	102	Bar Shear Operator Small
	101	Circle and Gauge Shear Operator

#1 Advance only if experienced on 179 or 151
#2 To advance only if seniority carried in Welding Department
#3 To advance only if experienced on 166
* Advance only if experienced on 151
** Carries seniority in major department prior to this assignment

FIG 42 1 Promotional chart of R G Le Tourneau, Inc , Peoria, Illinois

too well, he is likely not to fit the original niche after the job has changed entirely through the interplay of new forces or new ideas in the business The specifications should include a consideration of minimum, rather than maximum, qualifications of the employee and a full statement of the conditions under which the work is done in order that the interviewer's memory may be refreshed when he is seeking a person for a job, they should indicate the pay and the lines of promotion which seem to be open for the job (see Fig 42 1) Effective job specifications aid, not only in the selection of the employee, but also in his transfer and promotion If they are intelligently utilized by the employment department, they aid in preventing the overselling of a job to a prospective employee, with the result that he leaves within a short time after starting to work

The employment interview[3] There can be no cut-and-dried method of interviewing Each person must be treated in a different manner and in a way which seems best to fit his individual case The successful interviewer is one who can put the applicant at ease and get him to talk freely about his experience and desires In all employment work the major task of the management is to make the employee or prospective employee act in a wholly natural manner and "open up" in conversation It is desirable that all features of the employment office be constructed with this idea in mind When the majority of persons being employed are women, the interviewer should be a woman, and when the majority of applicants are men, the interviewer should be a man, inasmuch as workers seem to express themselves more freely to members of their own sex This general rule holds true also for the higher positions in the personnel organization Courtesy on the part of members of the employment staff is a fundamental necessity, if the plant is to be regarded in the community as a good place to work

The interviewing office should be clean and comfortable but avoid ostentation and display An employment office of a bank or a department store may well be more elaborately furnished than that of an industrial plant The interviewer should sell the plant to the applicant but not oversell either the plant or the job The basis of many other personnel activities is to be found in the impressions gained by the worker in his first few days on the job If the interviewer is successful in his relations with the workers whom he interviews, he can develop an attitude toward the plant which will go far toward making the worker feel at home during

[3] See Guy Wadsworth, Jr, "How to Pick the Men You Want," *Personnel Journal*, Vol 15, March, 1936, p 335, for a more detailed discussion of this subject Also see Scott *et al*, *Personnel Management*, McGraw-Hill, New York, 1954, Chap 7, "The Interview as a Tool of Personnel Management", American Management Association, *Research Report*, No 4, 1944, pp 33–35

the first trying days No matter how badly a worker is needed, it is distinctly poor policy to oversell the job by exaggerating its good points or by consciously or unconsciously not mentioning its bad points The bad points will be discovered quickly by the worker If he is not prepared for them, there is the likelihood that they will appear even worse to him than they actually are

The application blank [4] Application blanks should be made as simple as possible, the questions asked should all have a bearing on the applicant's fitness for a particular job or right to membership in the organization Personal questions, which may aid the interviewer in determining the desirability of the applicant should, however, be asked in the interview rather than on the blank The application blank should be handed to the applicant in a way that will secure his cooperation in filling it out, rather than have the effect of making him look at it as a piece of useless mechanism which must be filled in before the real business of the day can start [5] If the interviewer is really to learn pertinent facts, the applicant must be made to feel at ease The application blank may readily be used by the interviewer as a means of beginning the conversation with the applicant in an attempt to find out what kind of person he really is Such applications provide a valuable file of eligible workers for whom there are no immediate openings When the application blank is used as a file for future prospects, it is necessary to recheck this file at stated intervals to keep it alive One method is to send out postal cards at the end of a given period asking the applicant to notify the employer if he still wishes to be considered for a position If there is no reply or a negative reply, the application blank is destroyed

Employment tests [6] *Tests are frequently of more value in determining a minimum below which the applicant has little or no chance for reasonable success than in rating the relative merits of applicants whose scores are high* (Fig 42 2) Mental tests, such as general intelligence tests, are of little

[4] See American Management Association, New York, *Research Report,* No 16, 1950, pp 38–56, also National Industrial Conference Board, *Studies in Personnel Policy,* No 87, 1948

[5] Some employers have the applicant fill out only an abbreviated preliminary application blank until he has been interviewed by the employment office This practice saves much time and prevents annoyance to many applicants If the employee is to be hired, either he or an employment representative fills out a detailed application blank, which is made a matter of permanent record If the applicant is not employed immediately but appears to be a desirable man for future call, he may be requested to fill out the more complete card

[6] See Scott *et al*, *Personnel Management,* McGraw Hill, New York, 1954, Chaps 15–18, see also National Industrial Conference Board, *Studies in Personnel Policy,* No 97, 1948

proven value in the selection of workers, except for setting minimum standards, thus eliminating certain applicants Even in this connection care must be exercised An individual who could not learn certain skills under competitive conditions within the required time limits imposed by industry may have acquired these skills under less exacting conditions and be an average worker He may fail the general intelligence test and yet pass the performance test Intelligence tests may give some idea of mental

Courtesy Oldsmobile Division of General Motors

FIG 42 2 Applicants for Oldsmobile employment take tests for manual dexterity

quickness or general knowledge, but they have not been developed to constitute a convincing test of fitness for specific jobs Mental tests which are designed to check a particular ability may be regarded as somewhat more successful Thus a test which indicates quickness of perception may be utilized as a partial guide in hiring persons to do assembly work on small parts These foregoing statements should not be interpreted to mean that psychological tests should not be used in employment but that too much should not be expected of them As a matter of fact, psychological tests ought to be employed much more generally than is now the practice, but they should be used with discretion and as aids, not final determinants in themselves

Trade tests, which presume to test directly the abilities of the applicant for the job by having him do some work of the kind in which he is sup-

posed to be skilled, unquestionably eliminate the bluffer But frequently it is necessary that a worker be given a chance to produce over a long period, because of the peculiar type of work or arrangement of machinery in the plant, or because of the scarcity of skilled workers at the time A large food distributor devised a simple test taken from actual computations required of route salesmen It was found that those who made four or more errors within the allotted time were almost certain to have difficulty with record keeping and making change On the other hand, a perfect score did not insure a successful route salesman or well-kept records The test eliminated the ones who could not perform, but it did not insure that the others would perform Performance tests are valuable for simple kinds of work, such as typing Trade tests, which consist of showing the applicant a picture of a machine and then asking him a series of questions concerning it, or asking him for other similar trade information, are somewhat more valuable, provided the test is used as a part of the general interview and not given like a civil service examination Although the poorest worker may readily pass the best examination if his mind happens to run in such channels, nevertheless, if properly devised, such tests may gauge the actual ability of the applicant with considerable exactness

All methods of character analysis by means of physiognomy have been proved useless, and most advocates of these methods found to be complete charlatans Any test based on such ideas is in reality only making the applicant for employment subject to the fundamental or acquired prejudices of the interviewer On the other hand, there are some tests that aid materially in detecting personality deviations The Humm-Wadsworth test is one of the best known of this type of test It cannot be used by the average interviewer but requires a highly trained psychologist to interpret the results Relatively few employment interviewers are qualified to give and interpret psychological tests A trained psychologist should be used at least in a consulting capacity when psychological tests are a part of the employment program

Physical examinations In a survey in 1952 made by the author, 86 per cent of 628 companies answering the questionnaire gave physical examinations to all new employees In plants having physical examinations of applicants, with a doctor always in attendance, this examination may readily be given before the worker is finally employed It is wasteful to spend the time necessary to fill in all employment records unless the applicant can meet the physical requirements for the job In plants to which the doctor pays only periodic visits, the examination may come after the worker has been provisionally on the job for a day or two Physical examinations are largely used today, not as a means of complete rejection, except for communicable diseases, heart or respiratory disorders,

and a few physical handicaps, but as an aid to intelligent placement and follow-up Physical examinations prevent workers from being assigned to jobs which are beyond their strength or to which they are peculiarly unadapted from the physical standpoint, when they might as well be assigned to tasks which they can satisfactorily perform Many organizations have been using complete physical examinations for 25 years On the other hand, there are some communities where physical examinations for jobs are relatively unknown In communities where employment physical examinations are not generally used, workers may object to being examined This opposition can usually be overcome when the true purpose is explained by the interviewer

Introducing the new employee to his job[7] The training and induction process for a new employee begins in the employment office One of the most common ways of beginning the induction program is by giving the new employee a booklet which may have any title except "Regulations" Some concerns place the name of the employee on the cover of the book A personal introduction of the worker to the man under whom he is going to work is a necessity Either the foreman or the employment-department representative should be careful to introduce the new employee to those around him and to show him the facilities for his personal comfort, such as locker rooms and washrooms, as well as those aspects of plant routine which intimately concern him, such as entrances, clocks, methods of securing pay, and various service features Not only should the worker be properly introduced to his job, but he should also be carefully followed up, especially during the period immediately after his employment That is the time of most difficult adjustment, during which the heaviest turnover takes place In some plants, representatives of the employment department, sometimes even the interviewers themselves, go to the various departments and talk with those who have been recently hired In such talks an attempt is made not only to secure the reactions of the worker to his job but also to check up on the judgment of the employment department, so that transfers may be made, if necessary and advisable, at the time when they will do the most good

Certain reliable employees in each department who have demonstrated their interest in their fellow workers may be designated to aid the new employee in getting adjusted to his new environment This sponsor accompanies the new worker to the lunchroom, shows him the locker room, explains the many rules and customs that have grown up in the department, and in general conveys to the newcomer the idea that there is at least one member of the group on whom he may call for guidance and upon whom he may look as a friend The sponsor may be paid a nominal

[7] See Scott *et al*, *Personnel Management*, McGraw-Hill, New York, 1954, Chap 19, "Introducing the Worker to His Job"

sum for this service, or he may be granted certain special privileges, such as additional days of vacation with pay, permission to leave and enter the plant without punching a card, or special parking privileges The assistant foreman or group chief may assume the responsibilities of the sponsor, especially in relation to most of the auxiliary services

Transfers, promotions, and discharges Lines of promotion should be clearly defined where possible and a sincere effort made to create a real promotion policy Frequently simple promotion schemes are effective, such as transferring a worker from dirty or greasy work to clean work, or from a night shift to a day shift One reason why a well-developed system of promotions and transfers is necessary is that, if some such scheme is not worked out, there will be a tendency for the department head to keep his best workers in the jobs that they hold He may seek immediate low cost rather than ultimate low cost If morale is important to ultimate low cost, as it unquestionably is, promotions are necessary, for nothing builds morale more readily than does a real promotion plan This does not mean that personnel should never be brought in from the outside for executive or subexecutive positions On the contrary, if an organization fills all executive vacancies from the ranks, it may lack the drive that comes from new ideas To promote solely from within lays an especially heavy burden upon initial hiring If men capable of rising in the organization are not hired at the lower levels, they will not be available for promotion when a vacancy arises

Promoting from within tends to adjust the working force to absorb at the lower levels the work of the promoted employee Somewhat more than the required number of men is usually carried in large departments, particularly on the lower levels among day workers or even semiskilled workers In such situations the promoted employee is seldom replaced The same production is usually turned out with the reduced number of men, resulting in an increased efficiency per man A promotion scheme, including a line-of-promotion chart, cannot always be drawn up and posted, particularly in small organizations Nevertheless, an unofficial plan can be followed even though a formal organized program is not published The aim is to make sure that the worker has the maximum responsibility and earnings, and the firm has the benefit of his greatest ability In working out such a program, quantity and quality of work, length of service, attendance record, age, and physical and mental fitness must all be taken into account

Discharges, quits, and layoffs In our 1952 survey of personnel practices it was found that 80 per cent of the companies had exit interviews [8] In many organizations the policy is that the department head may discharge

[8] See Scott *et al*, *Personnel Management*, McGraw-Hill, New York, 1954, Appendix A, Fig A 7

an employee only from his department In principle this program is sound, and, when it is carried out in good faith by all parties concerned, few if any serious disciplinary situations arise The foreman is jealous of his reputation, so is the workman Both parties are anxious for a chance to "save face" Each man desires not to lose status in the eyes of his associates When possible, it is best to transfer the worker to a division of the plant as far removed from his original job as is practical Each party usually feels better about the matter when the employment officer can tell the worker that his former foreman recognizes that he may make good in another department and has recommended that he be given a transfer if possible A skillful employment adjuster frequently secures the coopera-tion of the foremen to the extent that he will call the employment office before discharging the worker

Adequate records should be made of all discharges They may well be signed by the foreman, the superintendent, and the employment officer, with any other witnesses who are available Such records may be invaluable later in a hearing before the National Labor Management Relations Board if the company is charged with discrimination because of union activities In some states unemployment compensation does not become payable so quickly when an employee is discharged for cause Unemployment compensation now makes it highly desirable to have accurate records of employees' quitting of their own accord Many times men are laid off from the working force of a department because of a reduction in its work but can readily be used in other departments of the concern In such cases an orderly procedure, rather than a mere dismissal of the employee, will frequently result in the retention of many persons who can be used in other positions

Labor turnover *Net labor turnover*, the most commonly used term at present, may be defined as the number of replacements per 100 workers in the average working force There are several other definitions, but the one given is in quite general use The formula for computation is

$$\text{Net labor turnover} = \frac{\text{Total replacements}}{\text{Average working force}} \times 100$$

$$T = \frac{100R}{W}$$

The Bureau of Labor Statistics of the Department of Labor collects these data and publishes a monthly index for the entire United States broken down into major manufacturing industries The figure may be expressed on a monthly or on an annual basis Unless otherwise specified,

the annual rate is used Although this index is by far the most reliable one available on a large scale, it is subject to certain limitations It is a crude unadjusted index and does not take seasonality into account Again, it does not distinguish among the causes for labor turnover Replacements of all types, regardless of cause, are lumped together The cause of replacements is of major significance for remedial personnel control This fact has led many employers to keep a special refined turnover rate for their own guidance In this case their refined net turnover rate is the ratio of the avoidable separations to the average working force (per hundred) This formula is

$$T = (S - A)100/W,$$

where A stands for unavoidable separations, S for total separations, and W for the average working force for the period

Labor turnover data, as such, have little significance The important thing is to interpret the data and to strive to remove the causes The exits should be carefully subdivided as to voluntary withdrawals, layoffs, and discharges It is in the subdivisions of these main causes of exits that the most valuable data will be secured for the development of the personnel policy Whether the voluntary withdrawal is due to dislike for the work, a "better job" (which frequently should be interpreted "higher pay"), conditions at home, or other reasons should be fully investigated before the employee is allowed to leave Sometimes the real reason cannot be ascertained, but at other times, if as much care is given to the interview when quitting as is given to the interview at selection, some real information will be secured for policy determination In addition to a compilation of causes of turnover, the employment department can prepare other interesting and valuable statistical information, such as an analysis of the working force according to earnings, length of service, or any other basis desired These analyses can also be combined with turnover statistics by departments as an aid in policy formulation and better selection

EMPLOYEE SERVICE ACTIVITIES

Objectives The only excuse for management's including service work its industrial program is that it will make the employees a group of tizens better able to carry on the productive processes, or that it con- .tutes a development which has been approved by the express will of the nployees A safe principle for guiding the inauguration of service :tivities is to have them grow out of the work situation and be in most stances the result of employee cooperation In all instances a more vorable attitude will result if the employees participate in the determi- ition of the general nature of the activities The term "welfare" should ot be used in referring to service activities Likewise a paternalistic titude should be avoided *Service work includes all those activities hich are not directly concerned with the worker in his relation to produc- on but which make the plant personnel a healthier, sounder-thinking, ore forward-looking group*

First aid and medical service The major objective of the medical rvice is to help keep the worker in good health and on the job Preven- ve medicine plays a leading role in the industrial situation Naturally, medial medicine also is practiced Industrial physicians should be al- wed to lay stress on health complaints made by workers and not wait r sickness disability Surgery, in the face of disability statistics, certainly quires much less stress than ordinary sickness Real occupational dis- ses constitute a very small part of the sickness disability occurring among orkers It has been found that sickness causes 20 times as many cases absenteeism as accidents and is reponsible for 7 times as much loss of ne from work True, the greater portion of sickness disability among orkers is extra-industrial in nature and is equally prevalent among lults of like ages and sexes in the general community, perhaps more so, it a considerable part can be greatly influenced by industrial environment id methods of personnel supervision and, as such, is capable of consider- ole reduction in the matter of days of absence from work [1]

[1] Adapted from address by Emery R Hayhurst, M D , Ohio State University and ate Department of Health, Columbus, before Conference on Women in Industry, *pecial Bulletin No 10,* Pennsylvania Department of Labor and Industry

If the confidence of the workers can be secured so that they will report to the dispensary when they first feel ill, a large share of absenteeism will usually be eliminated, and the spread of an epidemic within the plant may possibly be checked. Communicable diseases demand practically daily watchfulness, with foremen instructed to be observant. Likewise, health officials must be quickly informed of epidemic or multiple illness of all types. Provision should be made for treatment of trivial illnesses, first aid, dental prophylaxis, and ocular attention of a preventive and emergency nature, as well as the usual surgical treatment of minor injuries. Except in isolated communities, as a rule, major surgery and sickness should go to outside hospitals or elsewhere. Finally, compensation approvals must pass under the physician's scrutiny.

A medical department can do much to reduce compensation claims and loss of production time, but only if it is skillfully directed. Industrial physicians and nurses must understand the human side of their daily contacts. They must at least be given a cheerful place in which to work, and one that is central enough to make it convenient to all the workers. It has been found impracticable for most plants employing fewer than 500 workers to employ a physician full time. Plants employing from 500 to 2000 workers may or may not employ a full-time physician, plants with more than 2000 workers almost uniformly do.[2] The per capita costs for first aid and medical services range all of the way from $4.50 to $16.00. Naturally such a wide variation represents a marked difference in the medical and first aid services rendered. These figures cannot be viewed properly without considering the reduction in compensation claims and lost time and the increase in general contentment, due to the good health that such departments bring.

The industrial doctor and nurse are in a peculiarly advantageous position to counsel employees who are under emotional stress or suffering from imaginary ills. They may also advise management regarding plant conditions that need investigation. The checking of causes of absence may be done by a factory nurse. The only possible excuse for entering a workman's home when he does not report for work is to render assistance if he is sick. If it is found upon calling that the worker's absence is due to any other cause, there is but one procedure, namely, to withdraw promptly. Any other action is paternalistic to an impossible degree. Nevertheless, a clever factory nurse can secure much useful information in making her rounds, and her value in reducing absences is not confined to aiding ill workers to return to work more promptly. Her visits have a moral value, too, inasmuch as they indicate more strongly than any amount of regulation

[2] National Industrial Conference Board, *Research Report No. 37*, pp. 10–11.

by the management the importance of being on the job. The visiting nurse and doctor serve as the basis for administration of sick funds maintained by any mutual-benefit association in the plant. The nurse should also be closely in touch with any charitable organizations in the community which might be interested in aiding workers whose illness has left them temporarily in bad financial situations.

Recreation. Recreational activities that arise out of a natural desire of the employees may readily command the support of the personnel division. Practically any activity that people engage in outside of their

Courtesy The Champion Paper & Fiber Company

FIG. 43.1. Pavilion that will seat more than 1000 employees at a banquet. This structure is used for many purposes.

work environment may be a legitimate recreational activity for a business group. These activities may include dancing, music, or speeches during the noon hour, plays, band concerts, or dances given by workers at intervals throughout the year, or the development of clubs and clubhouses (Fig. 43.1). Any expensive program such as the maintenance of a clubhouse is likely to engender ill will unless the wages are as high or higher than the prevailing rates in the community. If the plant is properly situated, and if all fundamental conditions are right, there is no feature of service work that will do more to secure the mutual understanding of all elements within the plant than will a club. If this is to be true, however, it is essential that all employees, whatever their plant status, have access to its facilities.

If professional talent is available, it may be called upon infrequently for short concerts during the noon hour with satisfactory results. Plays and dances are valuable if they are fostered by the employees through organizations of their own, which call upon the service department only for guidance. Such activities are particularly workable in small towns,

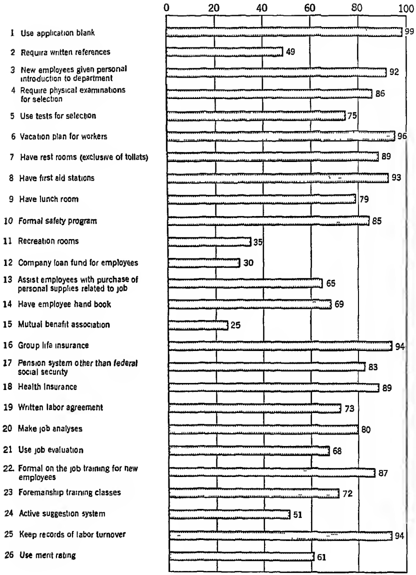


FIG 43 2 Personnel practices in 628 companies

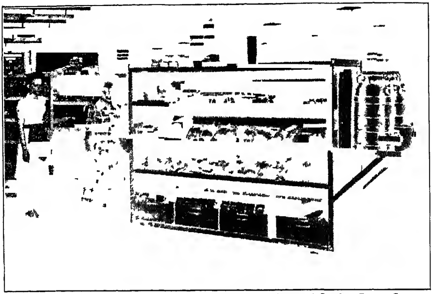
however, the employees of Western Electric Company, Hawthorne Station, Chicago, have had remarkable success with them Interdepartmental competitions tend to raise the spirit of the departments, and girls' or men's basketball teams, bowling teams, and softball teams are particularly successful Athletics develop health and encourage that most valuable asset to any industrial concern, teamplay They develop plant consciousness and

Fig 43 3 Cafeteria

leaders If plant teams are formed, the tendency toward professionalism and the hiring of workers merely for their athletic ability must be guarded against Even teams composed of bona-fide employees tend to make the winning of games their primary interest during the playing season At times this definitely interferes with the productivity of the individual workers involved In small towns, where the company team is in reality the town team, these objections are frequently outweighed by the good will which the team builds in the community Nevertheless, too much time, too much attention, and too much money can readily be bestowed on athletic work that emphasizes competitive rather than health features

Restaurants, cafeterias, and lunch wagons Figure 43 2 shows that 79 per cent of the companies surveyed had lunchrooms The prevalence of lunchrooms has shown a steady growth over the past 20 years Since

profit is ignored, costs in factory restaurants are usually less than those in commercial restaurants Costs are usually based on the price of food and service, overhead being eliminated For the poorer portions of the working force and for women workers who are also housewives, the factory restaurant provides an opportunity to get at least 1 good meal a day The establishment of a plant restaurant makes possible the enforcement of regulations against eating in the workrooms In some industries, such as



Courtesy Cleveland Graphite Bronze Company

FIG 43 4 Lunch wagon

clothing factories, food-preparation industries, and drug and chemical industries, it is necessary to prohibit eating in the regular workrooms In most industries it is desirable to have a clean lunchroom of some type The cafeteria style of restaurant finds most favor because of the lower cost and the speed of its operation (see Fig 43 3)

The operation of the restaurant requires a high level of business ability or it will sustain a considerable loss other than the cost of space and equipment It may be contracted out to an individual or company provided careful supervision is exercised to see that the service is good, it may be run by a representative of management, or in a few cases a committee of workers may assume the responsibility for running the restaurant In one large midwest organization the restaurant and employees' club are operated by the purchasing department but are under the supervision of a committee representing the employees

The restaurant may easily become the center of many of the recreational activities If entertainment features are desired, they can be provided in the restaurant, either during the noon hour or at other times The restaurant can be made the center of employee or departmental functions

Courtesy Armco Steel Corporation

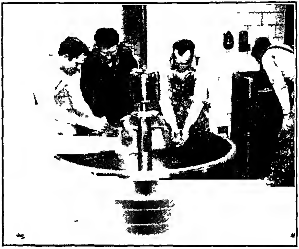
FIG 43 5 Locker room Work clothes suspended to allow for proper ventilation Lockers used for fresh work clothes and street clothes

and provides an assembly room upon which there is little desire or likelihood of encroaching In some cases certain of the small rooms, such as an executive lunchroom adjacent to the main restaurant, may be used for supervisory conferences and other educational activities

Some companies have lunch wagons (Fig 43 4) that make the rounds in the middle of the morning and the afternoon These lunch wagons serve sandwiches, soup, coffee, soft drinks, candy bars, and similar items The workers usually take an informal rest period at this time and buy items from the wagon or eat from their lunchboxes The time out for

these brief lunches does not retard production so much as some people think In many instances production is even greater than it would be with no time off

Restrooms and locker rooms In modern industry locker rooms and washrooms have become standard (Figs 43 5 and 43 6) During the rapid expansion of certain industries during World War II and the Korean War the shortage of metal made it impossible in certain cases to get adequate lockers This shortage was a constant point of friction so long as it



Courtesy Armco Steel Corporation

FIG 43 6 With a clean wash basin and running water workers are encouraged to observe scientific health rules

existed The locker room seldom came under the personnel division In many organizations these rooms are under the direct supervision of the department head and are kept clean by the janitor force just as is the rest of the department Regardless of the organizational setup, the personnel department will be interested in the adequacy of these facilities, just as it is in plant safety and sanitation Locker rooms should provide individual lockers, and washrooms should be constantly supervised and kept clean Restrooms for women (Fig 43 7) come under this heading and are uniformly desirable, if not maintained on too elaborate a scale

Employee financial aids Figure 42 2 shows that company loan funds, mutual benefit associations, group life insurance, pensions, health insurance, and vacations with pay are firmly entrenched in business The total cost of these so-called fringe benefits add up to a substantial percentage of total labor costs It must ever be remembered that all costs must be

recovered in the price of the good or service sold A paid 2 weeks' vacation is equivalent to a 4 per cent wage cost Social Security pension costs are scheduled to go from 2 per cent of payroll up to a statutory limit of 4 per cent Unemployment insurance costs may run to 3 per cent Private pension costs often run considerably higher than Social Security As we

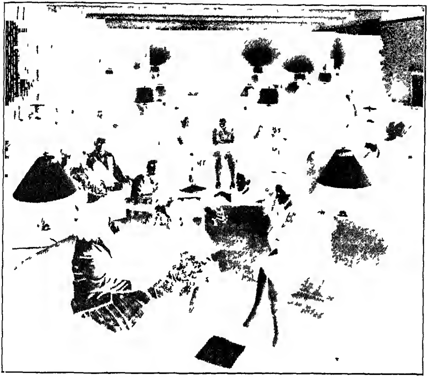


FIG 43 7 Restroom

go to press the mine operators are paying 40 cents for each ton mined into the miners' welfare fund These costs are not enumerated for the purpose of suggesting that they should be eliminated but to call attention to the fact that the employee's weekly monetary wage is not the only wage he receives His real wage includes all of the benefits listed and more These collective benefits paid through the employer make up a part of our social and economic standard of living In the main the worker's wage is not so high as it otherwise would be without these "fringe benefits", hence it may be said that their costs really are wage costs

Employee funds built up by their own efforts are valuable from the standpoint of the employee and the plant Such funds are those of the

building and loan associations and benefit associations, and savings funds Many companies have not been especially successful in operating employees' savings funds themselves, but these same companies may well urge the establishment of Christmas savings clubs, vacation funds, or building associations and can lend the time and experience of one or more of their executives or lawyers to act as an adviser to such groups The board of directors of such associations, to be successful, should be composed almost entirely of workers, with probably one representative of the management, who will sit for the purposes named Associations of employees created for savings purposes of one kind and another form an excellent foundation for the beginnings of cooperative management Savings funds usually work out best if they have some particular purpose in view, such as Christmas savings clubs Credit unions or workers' banks have been signally successful as a medium for saving for workers who have a surplus and as a source of funds at reasonable rates for workers in need of immediate funds They may be organized under either state or national laws The workers themselves *control* them Management may underwrite them to the extent of providing free office space and clerical aid in some instances, such as making payroll deductions for repayments or doing bookkeeping [3]

Group insurance Group insurance programs have grown in popularity during the past 20 years Figure 43 2 shows that 94 per cent of the reporting companies had group life insurance Many of the programs today are based on the earnings of the employees, for instance, employees earning $7500 and above may be eligible for $10,000 insurance, those earning $6000, $5000, $4000, and $3000 or above may respectively be eligible for $5000, $4000, $3000, and $2000 in group insurance Where length of service is the determining factor, it is not unusual for the company to bear all the expense, and the insured amount is usually lower This practice, however, is by no means universal The advantages to the employees are lower rates and no physical examination because the policies are taken out on the group basis One disadvantage of group insurance where the worker pays most or all of the cost, from the standpoint of the younger worker, is the fact that his rate is often higher than it would be if he bought the same protection alone This fact has encouraged company contributions, which is the prevailing system

Retirement plans Practically all business employees are covered by Social Security pensions Private pension plans have increased tremendously during the last 10 years They are very frequently related or tied in to some extent with the Social Security pension for manual workers

[3] The Federal Credit Unions are under the supervision of the Department of Health, Education, and Welfare

The details of the various pension plans vary with the desires of management and the pressures of unions Some of them require forced retirement at 65 and others permit the worker to work so long as he is qualified Forced retirement is quite popular It is open to severe criticism from a social and economic standpoint in many cases Employees contribute to company pension plans in some cases and in others the company pays all costs

In most cases pensions vary with the length of service of the employee and his earnings for the period They may also vary somewhat in terms of the amount of contribution (if any) by the employee There seems to be a tendency to have the pension equal from 40 to 50 per cent of the employee's average earnings for employees with a specified length of service, such as 30 years Naturally those plans that permit retirement at an earlier age than 65 reduce the amount of the pension

Company stores Most stores give their employees special discounts Companies that manufacture wearing apparel or other articles which employees are interested in purchasing usually maintain retail counters or stores at which employees may purchase the product at wholesale prices Other companies operate retail stores for the purpose of selling groceries and other necessities These stores are best run on a cooperative basis, if criticism and ultimate failure are to be avoided Occasionally these stores sell coal and other expensive necessities on the weekly basis Articles are usually priced on a basis of cost plus handling charge, with inventories taken frequently and prices adjusted accordingly Sometimes there will be an attempt to make a profit, with this profit turned over to the mutual-benefit association of the plant Some company stores remain open all day, when either workers or their families are permitted to make purchases Other stores are open only just before and after working hours and at the noon period A large store may utilize a box into which orders can be dropped These orders are filled during the day and are ready for the worker when he calls for them in the evening Company stores have never enjoyed wide popularity There are relatively fewer of them today than 15 years ago

44 · BUSINESS TRAINING

Extent of training in business Training is an ever-continuing process in all organizations that add new people or develop new procedures or processes Training can be used as a technique of control as well as of imparting information and developing new skills Educational training programs may logically fall into two divisions, namely, (1) specific training for job or occupational tasks, and (2) a general educational program which has as its objectives raising the general intellectual level of the group, transmitting company policies to employees, training in health and safety practices, promoting good citizenship, and developing morale Practically all business enterprises engage in both these types of activities in a limited way even though no formal programs exist Only the larger organizations can spend the money necessary to have an organized effort in all these fields

In some cases employees' clubs sponsor certain training activities or at least cooperate in the programs If a plant library, which is sometimes particularly desirable in small towns, is to be established, it can well be put under the supervision of some employees' club or association, although it should not be necessary that any employee be a member of the organization in order to secure the benefits of the library Education in thrift and the giving of sound financial advice are frequently possible but can probably best be carried on through the plant paper If there are savings funds or other similar plant organizations, they can best handle thrift education

The outstanding leaders in broad educational programs include such names as Western Electric, Eastman Kodak, Goodyear Tire and Rubber Company, the Ford Motor Company, the Chrysler Corporation, and the General Motors Corporation The Chrysler Corporation has the Chrysler Institute of Technology, the Ford Motor Company, the Edison Institute of Technology, and General Motors, the General Motors Institute of Technology These schools have as one of their objectives the training of executives and therefore may reasonably be classed under the specific heading of training for executives On the other hand, many courses are offered which are of a general educational nature Industrial educational programs are also fostered through cooperative courses at such schools as the

University of Cincinnati, Antioch College, Massachusetts Institute of Technology, and the Technological Institute of Northwestern University. Evening classes in colleges for strictly educational purposes have grown rapidly in recent years.

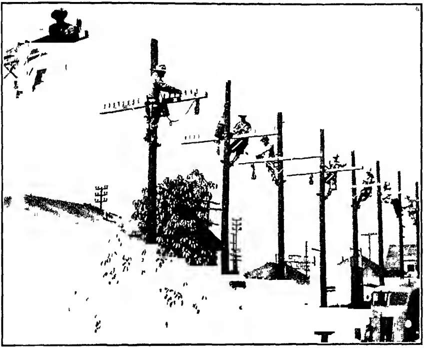
Indirect mediums of education. Bulletin boards, employees' papers, displays of products and models of processes, trips through the plant, counseling by the doctor or nurse, employment counseling, association with other employees, discussion groups, and other methods play a leading role in training. One of the most successful ways of disseminating personnel policies is through the plant publication. Such an organ will thoroughly acquaint the employees with each other and with the management, and it may be readily utilized as a means of expressing the fundamental concepts of the employer and the management and, frequently, the viewpoints of the workers as well. The plant paper is particularly valuable in this connection in organizations whose units are widely scattered, although its value is by no means limited to such cases. Of course, many plant papers are published which make no attempt to cover labor policy and are put out merely with the hope of increasing the good will of the employees in some general way. Although these papers are usually valuable, it is to be regretted that they do not make themselves additionally useful by considering labor policy. Not much space is needed for this purpose, and most of the magazine may still be used for educational, inspirational, and local-interest material. The first requisite of an employees' paper is that it be interesting, or it will serve no purpose. Most of the paper must describe employees' activities and relate interesting facts about the individual departments or the plant as a whole.

Methods of instruction. Instructional methods may be classified as follows: lecture, quiz, laboratory, project, conference, correspondence, and various combinations of these. The lecture method is effective for imparting facts, such as informing a group of new employees regarding the policies of the company. Slides and moving pictures may be used in connection with the lecture method, as well as with other methods. The laboratory method is particularly valuable in imparting certain skills and other information concerning machines and materials. Correspondence courses may be used where the employees are scattered and special information is to be taught. The correspondence method is the least desirable of all, but is the only one practicable under some circumstances. The conference method is particularly suited to the instruction of adults and has been popularized in executive training for the past 20 years.

The purpose of the foreman conference is to stimulate individual thought, develop initiative and the powers of attacking new problems on the part of the foremen by means of informal discussions in groups of about 12 men. The foreman conference

method differs radically from the conventional teaching methods ordinarily employed. A chairman, or conference leader, presides over each group, but he is not a teacher; his duty is simply to use questions in order to develop free discussion among the members of the group and keep the discussion from deviating from the desired goal. By the conference method, foremen teach themselves.

The conference method of foreman training is of particular value on account of its flexibility. The text material plays only a minor role, practical experience forming the background for every discussion.[1]



Courtesy American Telephone and Telegraph Company

FIG. 44.1. Practice makes perfect, and these telephone-line construction men are learning to do their job correctly and safely in a Bell System plant training class.

Training workers for specific jobs. Figures 44.1 and 44.2 show a group of telephone linemen being trained for their specific assignments. Figure 44.3 shows a very successful training school of the General Motors Truck and Coach Division. Each girl spent 3 days in this school before going out into production. Often workers, generally skilled in the trade, must be trained in a particular branch of it, if spoiled work, damaged machinery, or the risk of accidents is to be reduced to the minimum. Then, too, there are great potential gains in training workers already employed for ad-

[1] *Bulletin of Engineering Extension Division of Pennsylvania State College.*

vancement, and in training foremen and departmental supervisors toward a better understanding of the company and their jobs These are the phases of a general training program, and they must always be developed with the present and prospective sizes and the general policies of the

Courtesy, Southwestern Bell Company Southwestern Telephone News

FIG 44 2 On a pole inside classroom, student station installer runs drop wire through rings on cross arm before connecting wire to cable terminal while his instructor watches his work

organization in mind By far the largest amount of industrial training is for specific jobs Vestibule training is either for a specific job or related jobs

Apprentice training Apprentice training is probably the oldest type of training still in use (Fig 44 4) Such training is found today only in fairly large plants, which, because of the great number of all-round workers that they need, can afford to introduce training courses and stand the

expense of training workers who may not remain with them Thus such companies as the Westinghouse Electric and Manufacturing Company, the Goodyear Tire and Rubber Company, the General Electric Company, and the Ford Motor Company have found it profitable to develop apprentice courses In these courses are enrolled young men and boys 16 to 18 years old or more who are trained for 3 or 4 years, paid wages for hours of instruction, as well as hours of production, and then at the end of the

FIG 44 3 Vestibule training school

course are graduated as qualified journeymen and given in some instances \$150 or \$250 and their kit of tools

Apprentice training differs from the training for a specific job in that the apprentice is taught the "why" as well as the "how" and he is given a broad training which should enable him to do a wide variety of work within his field of specialization There has been a revival of interest in apprentice training since the beginning of World War II The Federal Government has a permanent committee on apprentice training, and employers have grown to realize that this program is particularly desirable in the training of men who will later develop into minor executives

The vestibule school The vestibule school is a preliminary-training shop especially designed for instruction, through which new employees are taken before being allowed to work on the production floors This type of school attained its greatest popularity during World Wars I and II

because of the large number of workers engaged in occupations with which they had previously been totally unfamiliar Sometimes this training takes place in a separate room and sometimes in the corner of the actual production floor, which is better when feasible, since it makes possible the immediate orientation of the new employee to the shop atmosphere of production (Fig 44 3) There are times when the vestibule school provides the best type of training, for example, when the job is unusually hard

Courtesy Studebaker Corporation

Fig 44 4 Father demonstrates the delicate accuracy of a micrometer to his son, an apprentice

to learn, as contrasted with simpler jobs within the industry, or when instruction seems to be impossible in the shop because of unusual conditions of production On the other hand it has many disadvantages, a few of which are as follows

1 It is difficult to reproduce actual working conditions

2 It is difficult and expensive to have sufficient machinery of each type in the plant set up in the school for instruction purposes

3 Because of the uneven demand for new workers, usually either part of the vestibule school is idle, or workers are rushed through it without the desired training

4 There is nearly always an adjustment period during the transition from the vestibule school to factory operations, especially if the worker spends long enough time in the vestibule school to be able to meet production standards When the worker gets only the initial training in the vestibule school, this criticism is not valid

On-the-job training For on-the-job training no additional equipment is necessary, but it is essential that the work be constantly checked to insure that training is actually being carried on Such training is usually given by the foreman or under his immediate supervision This is an ideal method of training under modern industrial methods, because the foreman, having been relieved of many of his previous duties, is left free for supervision and training, his logical work All foremen are not inherently successful teachers, but, if they have as complete a knowledge of their work as may be expected of them, they may readily be trained to impart their knowledge to others The Training Within Industry (T W I) Program and similar instruction for supervisors and shop instructors have raised the standards of instructing on the job Foremen are often aided in the instruction of beginners by an assistant particularly designated for that work, if the department is large, or by designated workmen in a smaller department Under the latter method it is necessary to reward the worker for giving instruction Success will usually follow training under the foreman, if it is made clear that this is one of his chief duties, and if means are provided for following up workers to see that they are, in fact, receiving training and are not being left to drift

Training for promotion A policy of "promoting from within" can be only so effective as the training designed to implement it Training for promotion arises from the demand for men to care for an expanding program, as well as for the normal replacements necessitated by deaths, retirement, quits, or other factors in expected labor turnover Means must be provided for the training of deserving employees for higher jobs With the vestibule school this may be accomplished readily, and such a program allows for the utilization of this school during times when it might otherwise not be busy Without the vestibule school it is necessary to sell the various foremen on the desirability of the training program and to follow up the program by accurate records to see that employees who are in fact successful are being prepared for advancement by their supervisors along the lines laid down by the promotion program The system of understudies has been advantageous in some organizations possessing a high type of morale, especially when the organization is expanding Many workmen as well as supervisors are reluctant to train an understudy for fear that he will take the job

Training supervisors and middle managers No organization can perform appreciably above the level of its foremen and middle management men, regardless of the caliber of its top management The foreman is the interpreter of the management to the men as well as the director of production itself In this dual capacity the foreman stands between management on the one hand and the rank and file of workers on the

other, a peculiarly difficult position and at the same time an influential one He is responsible for the standard of production and the quality and quantity of work, indeed, upon him depend not only the stability and effectiveness of the industrial effort, but also the fulfillment of the aspirations of thousands In many respects the training of subexecutives is more important than the training of workers in the mechanical skills, because executive and supervisory abilities are relatively more scarce than mechanical abilities These subexecutives may in part be trained for their tasks through the method of organizing the enterprise, as was explained in considering the committee idea in organization [2] More can be done through intelligently conceived plans of foreman and subexecutive training This training must primarily aim to develop the qualities of leadership It must broaden him and at the same time develop qualities of analysis that will enable him to visualize his job Regardless of the operation of the personnel department which endeavors to win the complete confidence of the working force, it is but natural and desirable that a large proportion of the workmen will look to the foreman as their leader and representative

Supervisory training should develop the foremen to qualify for advancement to positions of greater responsibility The training must be carefully developed, lest it result in the swelling, rather than the growing, of those being trained This unfortunate result is likely to follow unstinted reiteration of the great importance of the subexecutive to the business If the inducement of advancement is held out by the firm as the bait to attract the subexecutive to the training, there is likely to be much disappointment when it is realized that, for every possible promotion that may exist, there are a number of trained candidates Managements must be careful not to encourage the enrollment of their subexecutives in training courses advocating policies which the management is not ready and willing to see carried into effect It presents a sad situation to have the subordinate trained in scientific-management techniques which his superior spurns

Supervisory training may be conducted within a given company for its own supervisors or it may be conducted in a local college for supervisors from various companies The first plan is by far the more desirable where it can be adopted, but small concerns, located in large industrial communities, will find much to attract them in the second method In the one-plant groups an opportunity is provided to relate all discussions to the problems of the plant Where such groups do not provide the training which is desired for any particular supervisor, such a person may be

[2] See Chapter 6

individually advised to join some general group or some particular home-reading course, trade school, or evening course To secure the benefits of real training, however, it is essential that any groups organized within the plan be homogeneous, in order that topics of direct interest to all may be discussed Several training groups may well be organized If large groups composed entirely of executives are to be formed, it is necessary that the material discussed be confined to general subjects or to matters

FIG 44 5 A foremen's conference

that involve the coordination of activities of nearly all those present Group training courses, which are available in varying numbers depending on the size of the town in which the plant is located, and which may be recommended by the management, include Y M C A courses, university evening and extension courses, and courses maintained by groups of plants acting jointly

The conference method is recommended as particularly suited for training foremen and subexecutives Role playing has been successfully used by many training groups This technique is particularly valuable in training in human relations The subject matter for most of the earlier phases of the training will be selected from actual problems arising in the particular plant, such as quality control, securing suggestions from employees, good plant housekeeping, accident prevention, the foreman as a leader

of men, or the foreman as a teacher The more intimately these discussions are tied to the actual operations in the plant, the more profitable they will be Such meetings, if properly led, will result in real foremanship training In addition to material relating to the functions of foremen and the manner of handling their work, general material on economics, the policies and history of the company, and problems of the industry are introduced in the most complete training programs (see Fig 44 5)

Who should do the training? The ideal training director is the line officer responsible for production provided he has the time, interest, and ability to do the job He may be so hard pressed with other duties that a large part of the training load may have to be delegated to a training director in the personnel department The director of training should be a man of executive caliber who has the proper background for training It is a waste of money to have a $400 a month man try to train $600–$900 a month supervisors In smaller plants direction of training will probably be placed under the employment department At any rate, it is often a personnel function, although it deals intimately with production In it are involved numerous major relationships of the management and the workers, including fitness for the job, promotion, and interpretation of plant policy If a representative of the personnel department does the training he should work very closely with the line officers so that he will know the training needs and truly reflect company policies Training may well be a *tool of control as well as an educational process* For instance, if quality is low a specific series of conferences may be directed to quality maintenance

Cooperation with universities and colleges Such colleges as Harvard Business School, Northwestern University School of Commerce, University of Pittsburgh, and others conduct intensive programs for middle managers running from 3 to 13 weeks These schools do a fine type of work Many business enterprises that do not have active educational programs of their own encourage their employees to attend classes in the regularly established colleges and evening public schools of the community In some instances this encouragement takes only the form of approval by the supervisor or personnel department by noting such attendance on the employee's record In other cases the company pays a part or all of the tuition on successful completion of these courses In some instances these financial aids are given only when the courses taken are such that they may reasonably be expected to increase the efficiency of the employee in his present job or aid in his preparation for promotion In some communities that have no regularly established evening schools, employees are encouraged to take correspondence courses Specialized correspondence courses may also be promoted even where regular schools are avail-

able A word of caution should be made with reference to encouraging employees to take correspondence courses A survey made by the Minnesota Employment Institute showed that only 6 per cent of the persons included in their study finished the course Forty per cent gave up before the end of the first year, and approximately 75 per cent dropped out before the end of the second year

45 · MANAGEMENT AND ORGANIZED LABOR

The National Labor Relations Act The National Labor Management Relations Act of 1947 is a modification of the original National Labor Relations Act (the Wagner Act) of 1935 The revision of 1947 (the Taft-Hartley Act) was drafted to correct some of the abuses that had grown up under the administration of the original act The revision sought to restore to the employer the freedom of speech of which he had, in part at least, been deprived by interpretation of the act, not the act itself The new act also prescribed "unfair labor practices" for unions as well as for management The revised act also made unions responsible for their acts and provided specifically that they could be sued and also that an injunction could be issued against unions in certain cases

In spite of the dire predictions made by the unionists who wished to remain free to make their own rules governing their actions, unions have prospered under the Taft-Hartley Act and labor and management have learned how to engage in collective bargaining within the framework of responsibility A few union sympathizers (as this is being written) are still reported to take the law into their own hands, smash windows, and destroy property as an attempt to keep others from working in struck plants These cases are in a minority since most unions live well within the law of the land It was the unbridled excesses that led to the passage of the Taft-Hartley Act Continued excesses can only cause an aroused public opinion to pass additional legislation restricting the illegal actions of the irresponsibles

The right of collective bargaining has been clearly established as a part of the law of the land Practically all management representatives recognize this right It is true that some managers would still prefer to deal with their own workmen to dealing with outside professionals Even these managers recognize the legal rights of unions and bargain with them when they have been duly certified by the National Labor Relations Board

The relationship of the director of personnel or industrial relations to collective bargaining. While the responsible line executive is the logical person to negotiate a contract with a union, the burdens of top management may make this impractical In large companies union ne-

gotiating and grievance handling often requires the full time of several people In these situations the union contacts usually are made by a special department in the personnel division The major division handling all personnel matters may be known as the industrial relations division or the personnel division If the big unit is known as the industrial relations division, the smaller unit may be called the labor relations department or even the industrial relations department If the big unit is known as the personnel administrations division, the smaller unit is likely to be called the industrial relations department In a few cases the unit that negotiates union contracts is not directly associated with the other personnel functions but reports direct to the vice-president in charge of manufacturing

A few personnel directors feel that they cannot be so impartial as they should be in dealing with the union in their day-to-day relations under the contract if they negotiate it In any event, the unit that negotiates union contracts and handles the formal grievances is relatively small in comparison to the other personnel departments

Day-to-day union contacts The daily contacts between management and the union representatives depend upon a number of factors taken separately as well as collectively

1 Management's philosophy in relation to the acceptance of the union
   1 1 To tolerate and get along as well as possible with a minimum of contacts
   1 2 To tolerate and get along as well as possible doing whatever seems necessary, within the framework of good business, to keep production moving and to achieve the company's major objective
   1 3 To accept the union as a manifestation of employees' choice and, while preferring to deal with the employees, honestly striving to work with the union because of a recognition of the right of employees to representation
   1 4 To accept without any pronounced feelings for or against the union, thus striving to meet whatever situation arises
   1 5 To accept wholeheartedly and strive not only to get along with the union but to strengthen it, in the belief that the union can best perform certain functions of leadership among workers in the total industrial situation
2 The union leaders' philosophy in relation to ownership rights, management s motives, and total economic outlook
   2 1 Belief in private ownership and the right of owners to make as much profit as they can
   2 2 Believes in private enterprise but thinks that profits and managements' salary too high, without any real knowledge as to what profits or salary levels are
   2 3 Half hearted belief in private enterprise but strong leaning toward more and more government regulation and ownership, belief in codeterminism
   2 4 Belief in state socialism and opposition to private ownership in business, however, quite content to let time work out the change in ownership

2.5 Belief in radical change to state socialism (relatively rare)
2.6 Belief in communism (relatively rare)

3. Attitude in fact of management or union leaders toward organizational responsibility. Either management or the union may give lip service to democracy and decentralization of responsibility, yet keep a strong control over departments and smaller units. In such situations the local union may have little voice in contract making but must get approval of the national union. In a similar situation the department head or the plant manager may have his actions dictated by the plant manager or the home office.
   3.1 When both the unions and management strive to place responsibility as far down in the organization as possible, the actions will depend largely upon the personalities and philosophies of the two persons or groups of persons in contact with each other.
   3.2 When the central philosophy prevails on the part of both management and the union leaders, actual contacts at the point of operations are likely to be rather formal. In actual daily contacts there may be a high degree of informality between individuals if they have a sincere desire to get along and at times do not agree with the centralist approach.
   3.3 Either the union or management may have the centralist or decentralist approach while the other has the opposite philosophy.
4. Regardless of the philosophies there may be a clash of personalities at the actual contacts, giving rise to unnecessary frictions and strife not inherent in their basic approaches. On the other hand these same representatives may respect each other, even be genuinely fond of each other, and strive to get along well in spite of organizational difficulties that may tend to magnify differences.

From the above brief outline of various situations it can readily be seen that it would be almost impossible to generalize about union-management contacts. A few years ago the parent union group in a large city voted to go out on a sympathetic strike. In one of the largest plants in the city the local union head and his stewards reported the instructions to their plant manager, expressed regret at the decision, and helped to prepare the plant for the shut down. In another city the local union head in a meat-packing house called his men off the job without giving them time to finish processing the meat.

It is popular to say that management's attitude and actions set the pattern for the union actions. There is a lot of truth in this statement when management is dealing with men who believe in perpetuating private enterprise. It is unfortunate but true that management is not always so fortunate. Some few union leaders believe in the ultimate goal of state socialism or communism and work constantly to magnify friction, hoping to hasten the day when their dreams come true. Most of the daily contacts of union representatives and management are like most of the contacts between the same group of men on items other than on union matters—relatively peaceful.

Management has the responsibility for training its supervisors and labor relations representatives to work with the union representatives in those companies that have unions The attitudes of management's representatives have much to do with their success in getting along with the unions This by no means is to be interpreted that they must accede to all union requests either at the bargaining table or in the day-to-day relations Their acts should be within a framework of basic policies When these policies fully recognize the rights of employees to representation of their own choosing, the ground rules usually are relatively simple and direct Men learn to deal with each other in such an environment in a manner to minimize friction

The union also has a responsibility for training its representatives to deal with management Some of them are doing a fine job in their training Other unions are doing practically nothing along this line In these cases the union representatives usually have their pattern shaped by the actions of management's representatives (provided of course that the union's philosophy is not antagonistic to private ownership)

The foreman and the National Labor Management Relations Act Employees are guaranteed the right to bargain collectively with their employer by the terms of this act and its predecessor act By definition, Section 101, Subsection 2 (3) the supervisor is not considered an employee for collective bargaining purposes Section 101, Subsection 14 (a) likewise removes the supervisor from the employee class with whom the employer must bargain collectively The theory behind these exclusions is that the supervisor is management's representative This has always been the contention of most managers but it took the revision of 1947 to specify it in the law As a representative of management the supervisor and foreman is charged with the responsibility of knowing the terms of the law covering collective bargaining and also to govern his actions so that he will conform to the legal requirements It is not always an easy matter for a foreman who has never operated in a company with a union contract to approach his responsibilities to operate under a collective bargaining agreement with an open mind Nevertheless, he is charged with the full responsibility as management's representative so to act when such an agreement is signed The foreman has the same authority and responsibility to run his department under a union contract that he had before a contract with the exception of the items in the contract that may restrict his actions For instance, if the contract should provide that promotions will go to the man with most seniority provided he can do the job, the foreman must promote the man with the most seniority In case he fails to do so a grievance is certain to be filed The

mere fact that the foreman does not think that the man can do the job will not be enough to stop the filing of the grievance He is likely to be ordered to give the man an opportunity to demonstrate his ability to do the job A foreman has to be careful to avoid any charge of discrimination against a worker because of his union membership Aside from the foreman's being restricted to living within the terms of a union contract and not to discriminate against a man because of his union membership, he is free to run his department in the same manner that he would if there were no union He may discharge a man for any legitimate cause not associated with his union membership Of course, a man may not claim the right to do things in the name of his union that he is not entitled to do and thus escape the penalty of his acts

While the foreman may not discriminate against a man because of his membership in a given union, he also may not try to influence his men unduly in favor of one union instead of another He may exercise his right of free speech but this does not extend to making promises in favor of one union or making threats against a union

In spite of the restrictions that unions place on the foreman's actions, he still is the representative of management to the workers and in a very real sense a representative of his men to management Of course, the foreman does not represent his men in collective bargaining as such but he still may champion their cause in many aspects of working conditions, he appraises their performance and recommends them for merited increase in wages To the extent that the foreman truly presents the cause of his men for just recognition in all matters, other than unionism, management will be in a position to take the necessary steps to provide a working environment that should result in a harmonious union-management relationship A wise management consults its foremen, before going into union contract negotiations, for defects in the present contract from the standpoint of management The foreman should be equally prompt in reporting items that work injustices to his men Again, in many companies certain employees do not belong to the union While the union is certified as the collective bargaining agent for all of the employees in the particular unit, as a rule, it is not unusual for them not to represent, in fact, employees who do not belong to the union This places a special responsibility on the foreman to see that anything given to a union man be likewise given to the nonunion man who meets the same performance requirements All this adds up to is the fact that the foreman is responsible for truly representing the interests of all his men, union and nonunion, to the best of his ability

The duties of the foreman may briefly be listed as follows

1 To management[1]
  1 1 To transmit faithfully managerial policies to the men
  1 2 To transmit the worker's desires and aims to management (This is a dual function The foreman owes this responsibility both to the men and to the management)
  1 3 To get out the required production on time
  1 4 To maintain standards of quality by producing according to specifications
  1 5 To formulate plans and methods to increase productive efficiency
  1 6 To reduce all waste and scrap to a minimum
  1 7 To keep accurate records from which future action can be guided
  1 8 To render reports as required
2 To the employees under his supervision
  2 1 To provide adequate instruction in
    2 11 Company policies and procedures
    2 12 Correct methods of performing the required operations
    2 13 The next job ahead, to enable the workman to be eligible for promotion if a vacancy occurs
  2 2 To maintain satisfactory working conditions, cleanliness, order, safety, and an even flow of work
  2 3 To maintain discipline
  2 4 To promote cooperative effort and good will
  2 5 To represent the workers to management
  2 6 To promote and transfer impartially when opportunity presents itself
  2 7 To rate the workers fairly for wage determination
  2 8 To encourage suggestions and to give credit where it is due
  2 9 To strive to fit each worker into the job for which his capabilities are best suited
  2 10 To recognize individual differences and to provide inspirational leadership
3 For materials, buildings, and equipment
  3 1 To aid in the selection of material most suitable for use in the plant
  3 2 To aid in the selection of the best equipment for a given operation
  3 3 To handle materials efficiently so as to minimize waste
  3 4 To use equipment according to the best practice
  3 5 To inspect materials, work in process, and equipment (This does not take the place of the functional inspection of the other departments but is a part of the process of manufacturing according to established standards)

The foregoing tabulation is largely self-explanatory and illustrates the magnitude of the foreman's tasks in spite of the various staff and functional aids that have been provided Some of the specific factors in which the supervisor represents management to the men are (1) wages, (2) promotions, (3) assignment to a specific job, (4) safety, (5) layoffs and days worked, (6) recalls, (7) merit rating, (8) instruction on the job, and (9) working conditions

[1] This tabulation is adapted from *Department Management*, Chap 8, published by the General Motors Institute of Technology, Flint, Michigan, 1927

Early organized labor's attitude toward scientific management Frederick W Taylor earned the enmity of many union leaders by his unceasing efforts to increase production by making the work easier and teaching the workers the *one best way* to do the job

It was probably due to the fact that scientific management first developed in unorganized trades that union leaders of the time feared it and endeavored to destroy it They particularly attacked time study as the device which they claimed was symbolic of the attempt of scientific management to destroy skill and initiative Against time study, organized labor made a great drive in Congress in 1912 at the hearings before a special committee of the House of Representatives "to investigate the Taylor and other systems of shop management" Stop-watch time study had been adopted in the arsenals of the Army Ordnance Department through the leadership of General William Crozier, Chief of Ordnance It is probable that more persons were working under rates set by time study in the government arsenals in 1912 than in any other enterprise It was the example of the use of the stop-watch in the new and unorganized automobile industry, however, that led the unions to try to destroy its use nationally by prohibiting it in government work It was during these hearings that Taylor was put on the stand and said

"Do not understand for a minute that I am opposed to trade unions I am in favor of them They have done a great amount of good in this country and in England, I am heartily in favor of those elements of trade unions which are good I believe that the unions are misguided in a few respects One of the worst principles of the trade unions is that it is to their interest to deliberately, purposely work slow instead of working fast, with the object of restricting output"

Union attitudes toward motion and time study While union pressure caused Congress in 1912 to write a clause in the War Department appropriations bill forbidding the use of funds for time study in the War Department and this same pressure kept this rider in the succeeding bills for more than 30 years, on the other hand some unions have used scientific management techniques for many years The Amalgamated Clothing Workers have an excellent industrial-engineering department

The published attitudes of three unions regarding scientific management techniques are given below in summary form

1 The Steel Workers' Organizing Committee in *Publication No 2, Production Problems* (1938), p 10, states its position as follows

There is often dispute between management and men as to what is a fair day's work Men may complain of speed up The management charges that the men are lying down on the job The way to settle this kind of dispute is to set production standards by agreement

How is this done? First make sure that tools, materials and work are assigned so that work flows through the shop with little interruption Then take a man doing a given operation and tell him to work at his ordinary speed, without soldiering on the job but still in a way that is not too fast to keep up without strain or fatigue A representative of the union and a representative of the management should watch him and measure his speed There are various ways of doing this that provide the required accuracy and precision [2] There should be agreement about the results by both sides Observation may be repeated several times, or made for a number of men doing the same job On the basis of the records obtained, *and after* consultation with those doing the work, it may be agreed how long it ought to take to do the operation in question, and how many times it ought to be done per hour or per day Such an agreement then is adopted as the *production standard* for the job in question

2 The October, 1949, *Management Record,* Vol XI, No 10, p 442, National Industrial Conference Board, Inc, N Y, reports on union cooperation as follows

Cooperation with management is being stressed more and more by official AFL sources Most recent statement is that of AFL chief William Green in *The American Federationist* "Trade unionists must look to cooperation with management and increased output per manhour to increase their incomes and assure their progress In order to get this output, industries must provide improved equipment, better supplies, and better all-round working conditions all of which workers must use with increasing effectiveness and greater efficiency and concern for production cost"

The *Management Record,* Dec, 1951, p 426, also reports as follows

A significant remark made at the convention was that of President Philip Murray on the impossibility of standing in the way of technological change Unrehearsed, the speech came in response to a challenge from the floor of one item in a list of twenty-six contained in a resolution A delegate from a CIO railroad union challenged the CIO endorsement of the St Lawrence seaway on the basis that it might throw some of his members out of work Mr Murray's answer is viewed as one of his most penetrating statements on this subject "I do not know of a single solitary instance where a great technological change has taken place in the United States of America that it has actually thrown people out of work I do not know of it I am not aware of it, because the industrial revolution that has taken place in the United States in the course of the past twenty-five years has brought into the employment field an additional twenty million people

'So I say with all candor and all frankness, while opposition may be expressed to resolutions of this description, I nevertheless have no fear These are things that are inevitable The hand or the tongue of man will never stop them, but men must in the utilization of their common sense use these contrivances to advance our society and to improve the social and economic well-being of our national population We must move step by step and keep pace with these progressive steps as they are taken from time to time

"Twenty-five years ago or thirty years ago, when the automobile was coming into being, before you had a million and a half auto workers, President Reuther, I can

[2] Those familiar with these methods recognize time study by the use of a watch or by the use of a motion picture as two of the most practical methods A third method is the use of elemental times if they have been accumulated (This footnote is the author's and not a part of *Publication No 2, Production Problems*)

remember walking down the streets in the city of Pittsburgh and some fellow had an automobile, and they said, 'My God, what is going to happen to our society? Look at the blacksmiths, and look at the buggy makers, and look at the whip makers that will be thrown out of work' Disaster was going to overtake us because the automobile had come into our midst But the people accepted the automobile, and now I suppose there are ten times more people employed directly by the automobile industry and in the parts industry than the horse and buggy boys would have ever employed down through the ages—down through the ages

"And the same is true with respect to every other great industrial advancement that has taken place in this great country of ours, every one of them comprehends changes of an enormous and miraculous nature, and in the end the people derive the benefits of them"

3 In 1949 The A F of L Retail Clerks' John Wanamaker Local spent $6000 in advertising designed to bring more business to the store As we go to press Mr Paul P Milling, President of Local No 9, John Wanamaker (now the Employees Independent Union), states

> we have spent tens of thousands in newspaper advertising since then, which increased and multiplied to the tune of hundreds of thousands in free publicity by the generous response of our great American newspapers, magazines and periodicals, and then spread out to free time on radio, television and the state department itself, requesting me and a delegation of our union members to broadcast our union management cooperation to Europe, Asia and the silenced voices behind the iron curtain

Some union opponents to motion and time study claim that time study is destructive of the worker's skill, inasmuch as it substitutes the skill of the management for the acquired trade skill of the worker Not only may this situation result in the degradation of the worker, but also it is to be questioned whether it is desirable from the broad social standpoint to allow one small class in the industrial community to have all the knowledge concerning how jobs should be done It is pointed out that, after job studies, workers must conform to the methods of others Of course the answer is that, although it is true that all workers are taught the one best method known at the time, it is not true that they are prevented from improving upon this method, rather, they are encouraged to do so It is also true that President Frankel of Apex Electric agreed to let the union time-study men make the time studies which were checked by management's representatives At Apex, a fine spirit of cooperation has developed between the union and management around the establishment of standards

The author is convinced that many union leaders would be strong advocates of scientific management were it not for internal union political considerations Union leaders are able men as a group They are thoroughly capable of understanding the advantages of scientific management, but they are also realists and sensitive to their opponent's charge of "speed-up" The words "speed-up" arouse antagonistic sentiments in

the minds of workers regardless of the facts behind the charge Union leaders that are accustomed to piece rates and other incentive systems frequently pressure managers to install more scientific systems If union leadership continues to be in the hands of men committed to private enterprise, it is reasonable to expect other of their members to join the ranks of men *seeking the one best way*, the scientific way

The look ahead It ill behooves anyone to classify any large segment of people as being for or against anything that will raise the standard of living Name-calling converts no one to the ranks of those who would create more goods and services to be distributed among persons desiring and needing more goods and services Our farm population is probably our most stable single group of people They winced at seeing the pictures of tens of thousands of bushels of potatoes dumped by the government to keep prices high at a time when thousands of people were in need of more food and could not get it because of these same prices In spite of this antipathy of farmers to such practices and government regulations, the wheat farmers voted overwhelmingly in 1953 for government controls on wheat Paralleling the farm situation is that of organized labor While abhorring deliberate restriction of production and featherbedding, many of their more enlightened leaders have even a greater fear, namely, layoff and unemployment for large numbers of their people It is very much like the attitude of persons toward increasing foreign trade They are for it just so long as their labor does not have to compete with foreign labor for the market In other words, they are for it for the other fellow

In the final analysis, business is faced with rapid advances, plateaus in the progress, and then further advances At times we are prone to despair when we see economic stupidities being committed by people who ought to know better On the other hand, logical actions that move faster than the sentiments can follow cannot be maintained It should be the hope and aim of all people who would preserve those values that have made our country great that the values of scientific management and logic in agriculture, business, and organized labor become the sentiment, rather than the prevailing tendency to restriction The real future lies in an abundance to distribute rather than artificial restrictions in the hope of a more equitable distribution of a little Management should take the lead in this movement but management, even today, does not always take the lead Perhaps there will arise enough people in all groups that collectively can exert a powerful influence toward an application of true scientific management to the problems that confront our economic system Progress has been made during the past 50 years but we have a long way to go to learn how to harness our forces to move forward to overcome our obstacles

46 EMPLOYEE-EMPLOYER COOPERATION

Common interests Even those persons who are strong advocates of class consciousness (unless they are unalterably committed to the overthrow of our form of ownership and government) recognize that the employer and his employees have many points of common interests They recognize that steady employment can be had only if their employer can continue to sell his product They realize that quality and costs contribute to his ability to sell this product Most employees derive considerable pleasure from working for a firm that enjoys a good reputation in the community They are interested in its winning and holding this reputation What many employees do not understand is the actual relationship of the employer's profits to their wages Many of them think that profits are 2 or 3 times as large as they really are They seldom realize that their employer is just as anxious to think well of his employees and to be thought of favorably by his employees as they are in both of these relationships

Some employees endow their employer with a personality and attitude that is entirely foreign to him They tend to think that their employer spends hours trying to devise ways and means of exploiting them They really do not enjoy thinking of their employer in this manner for it is foreign to the American tradition These sentiments seemingly were intensified during the depression of the thirties when the business man was the popular whipping boy of the politicians and social reformers

We are now returning to a period where the workers' attitudes toward their employers are much closer to the traditional American attitude that all men are equal Unions remain stronger than ever but most of their leaders denounce the leftwing elements that were the apostles of destruction during the thirties Today there is a great deal of cooperation between workers and employers

In our last chapter we discussed the union relationship and the ways which unions and management cooperate In this chapter we are interested in areas of cooperation between the employer and his men as individuals or groups, as employees other than through the medium of the unions The unions as organized entities may encourage this cooperation, but most of it is not on an organized basis

Both a loyal employee and a loyal union member It was difficult for some employers in the thirties to realize that when his employees joined a union, they did not necessarily become disloyal to him as an individual nor to his company as a business entity These same employers now know that a man may have several loyalties For instance he may at the same time be a member of a family group, a lodge, a church, a union, a bowling league, and a work group At times these loyalties may conflict, as when the union calls a strike when the worker prefers to work and his family needs his wages These cases of conflict are not very frequent Most employees thread their ways into and through their various loyalties with relatively little difficulty It is this fundamental possibility of multiple loyalties that provides the basis of employer-employee cooperation

Suggestion systems [1] Men working in a small enterprise in close contact with the owner operator often make suggestions as a matter of routine These are frequently put into effect at once As the enterprise grows it becomes increasingly difficult to maintain this close cooperation It is almost impossible for the owner to get foremen who represent him in the same way that he conducted the department The formalized suggestion system seeks to enlist the constructive ingenuity and creative ability of the workers As a rule there are suggestion boxes placed in conspicuous and convenient places throughout the plant or store Alongside the suggestion boxes are placed suggestion blanks (Fig 46 1) on which the employee may make his suggestion and drop it in the box These suggestions are periodically collected and referred to the proper person for investigation and action

Frequently there is a suggestion committee that reviews all suggestions, decides what is to be done with them, makes recommendations for recognition or an award, and serves in a general way as the agency to encourage suggestions The secretary of the suggestion committee is usually its executive officer He or his representative, in a large plant, collects the suggestions, notifies the suggester of its receipt, and follows it through to its final disposition The suggestion may be incomplete yet possess considerable potential In this event the suggester may be assisted by the secretary of the suggestion committee or by an engineer assigned to help him

The suggestion blank may have a perforated slip at the bottom that is numbered the same as the main blank In case the employee for any reason does not wish to sign the suggestion, he may tear off the numbered stub and keep it until the disposition of the suggestion is made In this

[1] See American Management Association, *Research Report*, No 14, "Greater Productivity through Labor-Management Cooperation," 1949, pp 60–64

event the list of accepted suggestions is posted on the bulletin board by numbers The suggester may then present his stub and receive the reward, if any is paid for the suggestion In case additional information is needed regarding the suggestion, the suggester is notified by posting the number on the bulletin board and asking him to see the secretary of the

ARMSTRONG CORK COMPANY

Serial Nº 76802 **SUGGESTION BLANK** Reference No ____

PUT YOUR IDEAS TO WORK Date ____

Write your Suggestion Clearly and Concisely, making sure to note the Department or Building to which it refers
If it is necessary to make a sketch do so on separate sheet of paper
Read Rules on Back

I Suggest ____

I believe the above suggestion will result in ____

Name ____ Clock No. ____ Dept. ____

SAVE THIS STUB It is your record that this suggestion was made by you. Date ____

Name ____ Clock No. ____ Dept. ____
SIGN YOUR NAME HERE IN INK TO IDENTIFY YOURSELF IN CASE THIS COUPON IS MISLAID

Form 3163 4 51 Serial Nº 76802

FIG 46 1 Suggestion form used by Armstrong Cork

suggestion committee In case the employee still does not wish to reveal his identity, he may submit the required information by signing the number on his suggestion stub Most employees willingly sign their names When they hesitate to do so it is usually because of the pressure of fellow workers who fear that suggestions will cause a reduction in the number of workers required Some people file suggestions that pertain to working conditions and favoritism (in reality complaints) and hesitate to sign their names This is particularly true when the suggestion system is first inaugurated For instance, it is common practice for employees to make a large number of suggestions concerning restrooms, rest periods, and general working conditions This type of suggestion decreases in pro-

portion to other suggestions as time progresses, yet the means always remains for employees to suggest improvements in working conditions Some critics of suggestion systems point to the complaint type of suggestion as one of its faults It is better to give the dissatisfied employee a chance to get his complaint out of his system than to harbor it and possibly to magnify it all out of proportion to its importance

Suggestions when promptly followed up and disposed of provide an excellent medium for cooperative effort They can readily cause more discontent than good when not promptly handled One point of friction is for a suggestion to be rejected at one time only to be installed later by management The original rejection may have been justified but with changed conditions it was the logical thing to do at a later date The engineer who caused the later installation may not have known of the original suggestion One procedure often followed to avoid such situations is to have a standing published regulation to the effect that any suggestion not accepted becomes automatically dead within 12 months of the date of original submission To keep a suggestion alive the suggester may resubmit it Unless this type procedure or another more efficient is followed, employees will think that management is deliberately stealing their suggestions when they or others that are similar are later adopted

Another point of friction over suggestions is the reward paid for them It is highly important to have the system of rewards clearly outlined and generally understood One company pays its suggesters for all suggestions accepted and used 25 per cent of the net savings in 1 year Another company pays the suggester 10 per cent of the first year's savings and divides 15 per cent of the savings among other workers performing the work on which the improvement is made Other companies merely write the person who makes the suggestion, thanking him for his efforts, enter same on his permanent personnel record, and give him public acknowledgment in the company employees' magazine Where morale is high this approach may be even more productive of increased effort than cash payments One difficulty with cash payments is the fact that employees are prone to think that their suggestions are worth more than they really are In some cases it is exceedingly difficult to figure any saving even though the new method may be mechanically an improvement over the old one It is also difficult to place a price tag on suggestions that improve safety, general housekeeping, or working conditions For instance, the relocating of a light may reduce eyestrain but not increase production A suggestion to install showers for workers who work in a hot pressroom may result in a favorable employee acceptance, but it is difficult to estimate the saving

Cooperation in scrap reduction [2] Small items of scrap when multiplied by 5000 employees add up to a substantial cost daily and annually It is often difficult to enlist employee cooperation in this type of saving The contest technique in which records of departments or groups are posted daily often secures the desired results These contests nearly always are accompanied by considerable publicity in the employees' magazine Some companies have worked out bonus plans in which the employees share on some such basis as 50% of the reduced scrap below an established norm A few companies have included indirect materials and other items in their bonus for reducing costs

Cooperation in accident reduction [3] It would seem that employees would not have to be urged to assist management in reducing injuries to themselves but such are the facts of life Naturally, the individual employee would not do something purposely to injure himself or one of his fellow workers Nevertheless, he will take unnecessary chances on the assumption that the other fellow hurts himself in such situations but that he will not For instance, a punch press may be operated without a guard so long as the worker concentrates on placing the part into the die However, if his attention is diverted for a split second a finger, hand, or arm will be cut off It requires eternal vigilance on the part of supervisors to get workers to use guards on machines, goggles to protect their eyes, and respirators to protect them from poisonous gases or dust Constant supervision of the careless and the building up of a safety consciousness through group effort is the only way to get the workers to cooperate to save themselves from injury Safety contests and careful instruction are the common devices for developing this safety consciousness An accident usually happens to an individual and not to groups Safety requires individual observance of safe practices The group effort has a restraining effect upon the tendency of individuals to violate well-established safety rules A group that has acquired a basic safety attitude will tend to bring its individual members in line

Cooperation in quality maintenance Quality frequently suffers when workers are being paid on an incentive basis Inspection is highly essential in such cases Training in how to maintain quality while producing on a high level tends to promote quality maintenance As a matter of fact, the high producers in any group are nearly always also high in quality It is usually the relatively medium producers who are striving for higher production who shade the quality of their work Training plus close in-

[2] See American Management Association, *Research Report*, No 14 "Greater Productivity through Labor-Management Cooperation,' 1949, pp 85–88

[3] American Management Association, *Research Report*, No 14, "Greater Productivity through Labor-Management Cooperation," 1949, pp 71–84

spection is the best cure for this type of action One large Toledo manufacturer sent some of his union workers to visit one of their large customers who was complaining about the quality and threatening to cease to sell their product The returning workers were deeply impressed and passed on their impression to their fellow workers with favorable results

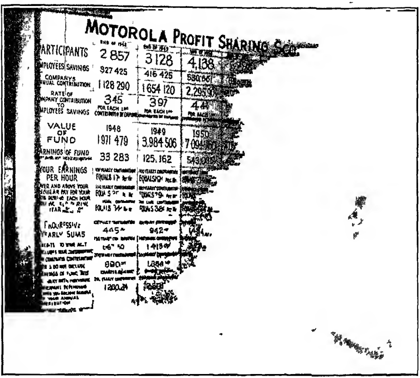
Management also must cooperate with workers in helping them maintain quality At times, defective maintenance of equipment contributes to defective work It is also necessary to provide workers with proper materials and supplies if they are to turn out the desired quality Frequently the showing of workers just where a particular part of close tolerances is used and the necessity for the requirements provides the incentive to the proper performance

Profit sharing Profit sharing is a form of employer cooperation with his employees in that he not only pays them their economic wage but also shares with them a part of his profits, thus giving them a part of the fruits of ownership (Fig 46 2) Profit sharing was practiced in the days of an agricultural economy when the tenant cultivated the soil on the "shares" basis This practice still prevails in our rural sections today Fishermen also share the fruits of their "catch" Profit sharing,[4] in its most acceptable form, implies an agreement between the employer and the employees under which the workers receive, in addition to their wages, a predetermined share in the profits of the undertaking over a given period The distribution of bonuses at Christmas or other times of the year, in the attempt to share with employees the profits of the enterprise over the period, has not usually proved a successful form of employee participation There is serious question regarding the advisability of giving the employee profit-sharing payments in cash when they are substantial This statement, of course, does not apply to such small payments as $25 The employee who receives such payments regularly soon begins to look upon them as a part of his wage and frequently spends them in anticipation of receipt When profits are not earned and hence cannot be distributed, the morale effect is likely to be bad, since the employee may have worked just as hard as when he received a substantial payment the previous year A better policy is to pay employees their share of profits in the form of a paid-up annuity This helps the employee build up his estate and will make an income available to him when he will no longer be earning wages Profit sharing is not a substitute for paying the prevailing wage for a particular occupation

Profit sharing is often used to arouse the interest of workers whose jobs are such that it is difficult or impossible to place them upon piece work

[4] See Senate Report No 610, 76th Congress, 1st Session, *Survey of Experiences in Profit Sharing and Possibilities of Incentive Taxation*

Such men are executives, delivery men, men in the shipping room, and, at times, salesmen By arousing the sense of participation, profit sharing is frequently used for some specific purpose in the business Thus it may be used to prevent the waste of materials, as it is when a concern agrees to split "50-50" with its employees any saving of material which they



Courtesy, Motorola Inc

FIG 46 2 Motorola profit-sharing scoreboard

effect Many managers regard profit sharing as a way to reduce labor turnover, by providing that only employees of a certain minimum length of service will share, and that these will share in accordance with their length of service

Some employers have come to feel that there is a wage for capital, just as there is a wage for labor, and that all earnings above a certain wage for capital may logically be distributed between capital and labor Under this assumption there would be no cause for workers to share in losses, provided only that some provision were made for their repayment before the workers again began to share in the profits

Management's objectives in profit sharing may be summarized as follows

1 To promote individual efficiency
2 To promote general efficiency
3 To develop a waste elimination consciousness
4 To encourage managerial efficiency
5 To develop a proprietary attitude on the part of employees, thus contributing toward the preservation of private capitalism, since a worker will not be likely to embrace an "ism" that takes away from him his own rights in private property
6 To provide a measure of security for employees
7 To reduce labor turnover
8 To foster industrial democracy
9 To encourage mutual cooperation and understanding between the employer and employees

Employee stock ownership One important phase of employee ownership has been the giving of the employees' share of the profits to them in the form of the company's stock Another method of employee ownership of company stock has been to sell it to them at a price lower than the market price and to let them pay for it by salary deductions Employee stock ownership leads to direct participation in management Any such plan should be carefully guarded and explained to employees concerned, particularly as regards a possible decline in the market value of the securities Furthermore, unless the number of shares which a given employee may own is considerable, the plan tends to become one for investment of the surplus funds of the employee, rather than of participation in management [5] This fact is indicated by the tendency of employees to sell stock, if it is in their control, when the market begins to decline A serious objection to worker ownership is the fact that it frequently operates in direct opposition to security If the worker is laid off for a long period because of reduced production, this layoff will usually happen at a time when the value of his stock is declining, as well as during a period when the dividend return is low Such a procedure also lacks the desirable characteristic of diversity The foregoing statements lose some of their force if the stock is given to the employee outright as a part of a profit-sharing program with the understanding that it is to be held as a long-run proprietary interest in the company Some people have advocated the issuance to employees of special nontransferable stock that has all the rights of common stock save transferability Under such a system, if an employee retires, he is permitted to exercise the option of exchanging his stock for regular common stock or selling his stock to the company at the current market price Stock-ownership plans are more successful as a

[5] See National Industrial Conference Board, *Studies in Personnel Policy*, Nos 132

means of participation among salaried officers than among wage-earners, as the officers are usually better able to understand the benefits of ownership and are usually in a position to own sufficient stock to arouse their enthusiasm for the scheme

Attendance During periods of prosperity absenteeism tends to become a serious problem When the workers are needed most they are present the least Such a situation arises because they are making more money than they are accustomed to and hence do not have the pressure of need to spur them on to be regular in attendance There is also the ease of getting another position that largely removes the fear of being discharged for poor attendance Studies have shown that attendance is maintained at a higher level by supervisors who devote a substantial amount of their time to the job of leading their men rather than to the mechanical phases of their work [6] The supervisor need not ignore the necessity occasionally for removing an employee who flagrantly absents himself from work On the other hand, most of his efforts are directed to helping his employees solve production problems, occasionally helping them in personal matters when his opinion is sought, and positive leadership in his department

Some companies have provided additional incentives for regularity in attendance such as prizes, additional days of vacation, special certificates, pins, and similar rewards both for the individual and for the departments Frequently departmental recognition enlists the group's efforts to maintain a high record [7]

Good housekeeping Good housekeeping is one aspect of successful industrial management where willing cooperation on the part of employees pays big dividends It requires very little more effort for an employee to deposit an empty cigarette package in a receptacle than to throw it on the floor The same applies to cigarette and cigar stubs However, this little extra effort on the part of the employees makes all the difference in the world in the housekeeping of a department The cooperation of employees usually can be secured when management sincerely manifests a desire to keep the premises clean and provides an adequate supply of containers, and sufficient janitors to remove the things that naturally fall on the floor from operations If management permits cutting oils to get on the floors from leaking machines, it cannot expect workers to be particular about keeping other things off the floor Some companies have painted the corners white and keep them immaculately clean as a symbol of their desire for general cleanliness Such an attitude tends to enlist cooperation

6 See *Harvard Business Review*, Sept, 1950, pp 42–48, 'Management Factors Affecting Absenteeism "

7 See American Management Association, *Research Report*, No 14, "Greater Productivity through Labor Management Cooperation," 1949, pp 55–57

47 INDUSTRIAL SAFETY

Safety in industry Management is keenly aware of the costs of accidents, as are the victims of the accidents The great problem to be solved is to get the individual worker at the point of operations to realize his personal responsibility Fifteen thousand workers were killed during 1952 in the course of their employment During the same year 2,000,000 were

COST OF ACCIDENTS REPORT

First Quarter 195

DEPARTMENT	101	115	118	120	128	603	623	652	691
LOST TIME	71 40	37 95	40 33	64 60	24 15	53 04	5 88	8 82	5 15
HOSPITAL COST	21 33	8 26	14 21	23 87	4 27	24 92	4 76	6 72	1 89
MEDICAL COST	128 00	—	44 50	250 50	—	53 00	5 00	12 00	3 00
COMPENSATION	—	—	—	—	—	178 50	—	—	—
TOTAL COST	220 73	16 21	99 04	348 97	28 42	309 46	15 64	27 54	10 04
HOURS WORKED	74778	29076	71402	53076	41159	24532	31523	23538	7718
COST 1000 MAN-HOURS	2 95	1 59	1 39	6 57	69	12 62	49	1 17	1 30
DEPARTMENT									
LOST TIME									

Courtesy H K Hilton Barber Colman Company Rockford

FIG 47 1 A cost record that is easily compiled by comparing departments

injured to the extent of being compelled to lose time from work The direct costs of these deaths and "lost-time accidents" were approximately $1,400,000,000,[1] the indirect costs were approximately $1,500,000,000 These indirect costs arise from damage to equipment and materials, production delays, and time losses of other workers not involved in the accidents The direct costs to society are made up of compensation insurance, including payments and overhead costs, uncompensated wage losses, and the cost of medical care An even greater loss was the loss in productivity of others near or associated with the injured person The figures

[1] The direct costs include wage losses medical expenses, and insurance and overhead costs See *Accident Facts,* National Safety Council, Inc , Chicago, 1953, p 24

given above are by no means to be interpreted as being mathematicall precise They are broad estimates that may reasonably be used to poir out the tremendous social and economic waste of industrial accident: The important consideration from the individual employer's standpoir (aside from the humanitarian considerations which are ever present) i his own cost Each employer should strive to set up cost figures coverin his accident experience each year (Fig 47 1)

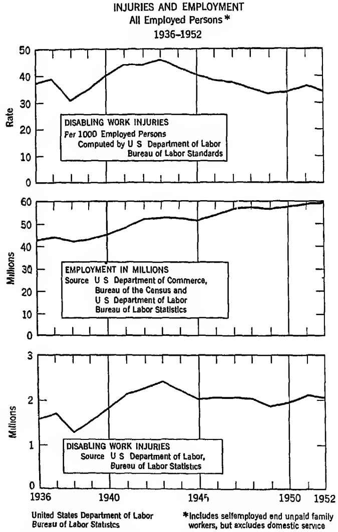


FIG 47 2 Injuries and employment, all employed persons, 1936–1952

Safety organizations The National Safety Council, Inc , was organized in 1913 and has enjoyed a long and successful career, holding a position of unquestioned leadership in the safety movement It is financed by the member companies The National Safety Council, Inc , collects statistical data regarding the causes of accidents and conducts a vigorous campaign for safe practices Its publications have been very helpful in promoting

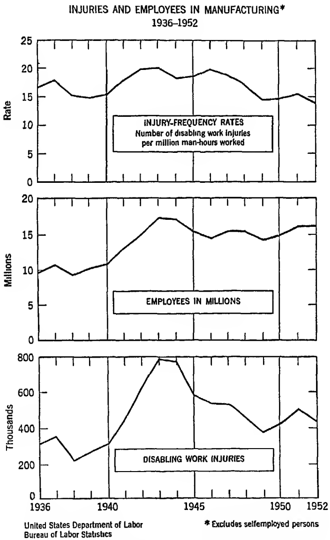


FIG 47 3 Injuries and employees in manufacturing, 1936–1952

the safety movement A large number of the full-tıme safety men are members of the Amerıcan Socıety of Safety Engıneers, an affilıate of the Natıonal Safety Councıl, Inc The Amerıcan Socıety of Safety Engıneers ıs an organızatıon that ıs strıvıng to raıse the standards of ıts members to a truly professıonal level The Amerıcan Standards Assocıatıon, formerly the Amerıcan Engıneerıng Standards Commıttee, serves as a clearıng house for standards It has become a federatıon of technıcal and professıonal socıetıes, trade assocıatıons, and some government agencıes

Trends ın accıdent reductıon Fıgures 47 2 and 47 3 show the relatıonshıp of ınjurıes to employment ın both severıty and frequency rates,[2] from 1936 to 1952 for ındustry as a whole Fıgure 47 4 ındıcates the remarkable reductıon ın accıdents for the members of the Portland Cement

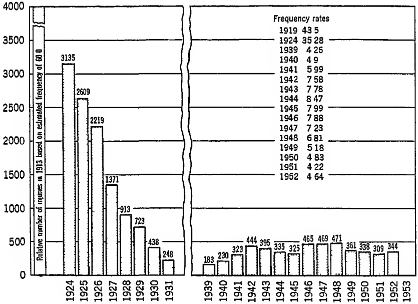


FIG 47 4 Number of ınjurıes to members of the Portland Cement Assocıatıon

Assocıatıon Fıgure 47 5 portrays the safety record of the combıned Du Pont plants for the years 1916–1952 Each and every one of these graphs shows phenomenal progress ın accıdent reductıon Certaın entıre ındustrıes such as steel, automobıle, cement, petroleum, publıc utılıtıes, and chemıcal have reduced accıdents to a place that ıs hıghly commendable Unfortunately, small busıness has not been so successful For ınstance,

[2] The frequency rate ıs the number of dısablıng ınjurıes per 1,000,000 man hours worked The severıty rate ıs the number of days lost per 1000 man hours worked

both the frequency and severity rates of businesses with under 50 employees are twice as high as in businesses with over 500 employees It is conservatively estimated that not more than 30 per cent of our work force is employed in firms having 500 or more employees This fact

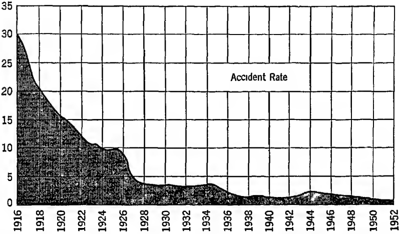


FIG 47 5 Accident rate of E I du Pont de Nemours & Company, 1916–1952

points to the most important field for reducing the accident toll The major causes for the high accident rates among small firms as reported by the U S Department of Labor in 1948 are

1 The small firm cannot employ full-time safety personnel

2 The small-firm executive carries a complex load and lacks the aid of a technical staff

3 He rarely joins such organizations as the National Safety Council or attends safety congresses

4 Small firms generally lack detailed cost-accounting systems and therefore the cost of their accidents is not brought out

5 The accident rate has to be extraordinarily bad in a small working force in order to yield a flow of injuries sufficient to arouse a management immersed in its manifold problems of sales, finance, and production

6 Small firms usually are less able to make expenditures for which prompt return is not assured [8]

Does the safety program pay? When it is recalled that workmen's compensation costs are lowered when lost-time accidents are reduced, it can readily be seen that the phenomenal reductions in lost-time accidents influence accident costs Safe practices should be followed even if they actually cost more than unsafe practices but such is seldom the case It

[8] *Safety Subjects*, Bulletin No 67, U S Department of Labor, Washington, D C, pp 4–5

is very difficult to determine the exact costs of accidents The direct out-of-pocket costs of insurance are readily available as well as all the direct costs of guards, the safety director's salary, and such items, but the indirect costs of accidents are very difficult to measure [4] There is also an additional cost that cannot be figured, namely the added labor turnover arising from employee's leaving when the accident experience is high Practically every large company in the United States has a formally organized safety program All of them have a vital economic and social interest in safety, even though a few may carry on their work through the regular line organization A bad accident rate may run into a substantial cost per capita To reduce this rate is to reduce costs The total costs of injuries average at least 5 times the sum of compensation paid plus the medical expenses For instance, if compensation paid was $200 and medical expense for the same accident was $100, the total cost to the employer, when figuring every factor, would be approximately $1500 [5]

Organization of the safety function One of the best and recent studies of the organization and function of the safety department was made in 1951 by the American Management Association [6] This report shows that in 33 per cent of the cases the safety department is an independent department reporting to top management Of the 67 per cent that do not report to top management, 78 5 per cent (or 52 6 of the total) report to the personnel and industrial relations department From a strictly organizational standpoint, there is little logic in placing the safety director under a top management official (other than the chief personnel executive when he is classified as one) save in those cases where accident hazards are of major importance, such as in a powder plant Even in these highly dangerous industries, the function may well be a department of the larger personnel division where the chief personnel man is of the executive caliber that he should be To place the safety director under an executive vice-president or the general factory manager may appeal to the vanity of the safety director in that he reports to a man of high status and thereby de-

[4] See H W Heinrich, *Industrial Accident Prevention*, McGraw-Hill, New York, 1950, pp 50–52, for his discussion of the 4 to 1 ratio of indirect costs of accidents The 4 to 1 ratio was found to be too high by Rollin Head Simonds in his doctor's dissertation, *The Development and Use of a Method for Estimating the Cost to Eight Producers of Their Industrial Accidents*, Northwestern University, 1948 He found the ratio "to be between 1 6 to 1 and 2 to 1, certainly not much over 2 to 1, however, the companies were weighted in the averaging" See also Rollin H Simonds, *Harvard Business Review*, Jan, 1951, pp 107–118, "Estimating Industrial Accident Costs"

[5] See Roland P Blake, *Industrial Safety*, Prentice-Hall, 1953, pp 22–29

[6] See American Management Association, *Research Report*, No 18, "Organization and Function of the Safety Departments," 1951

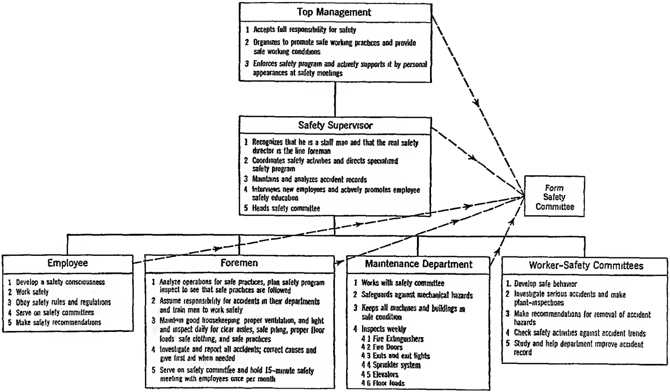


FIG 47 6 Safety functions

rives a personal status, but it definitely overloads a man who already has a great burden Instead of the safety director's getting more assistance in his work, he is likely to get less than when he reports to a director of personnel who has the status his position should command The functions of the safety department are illustrated by Fig 47 6 Figure 5 5 illustrates the relationship of the safety department to other departments in a factory Briefly, the more important things that management must do to prevent accidents are listed in tabular form below

1 Provide safe plant, equipment, and tools
2 Safeguard all machinery
3 Place no new machinery or equipment in operation unless full attention has been paid to its safety
4 Plan and arrange all processes and operations with careful attention to safety
5 Maintain a system of inspection to discover correctible hazards
6 Maintain safety-minded supervision
7 Train, educate, and stimulate its employees to follow safe methods of work and to take a sincere interest in the safety of themselves and their fellow workers
8 Investigate each and every accident to determine how best to prevent a recurrence
9 Make full and prompt report to the proper authorities of all cases of injury [7]

Occupational diseases The most common occupational diseases or ailments are dermatitis, abrasions, bursitis, synovitis, benzol poisoning, lead poisoning, and difficulties arising from silica and dust Each area and industry has its peculiar problem in relation to occupational diseases Occupational diseases in industry are relatively unimportant in comparison to accidents, being from 4 to 5 per cent of the total of health and accidental injuries Nevertheless, occupational health injuries constitute a very real drag upon the individual, society, and business The field of occupational diseases has not been explored so intensively as accidents It is not always possible to trace a given disease to the occupation unless poisoning, such as lead poisoning, is involved Society is becoming keenly aware of the broader implications of occupational diseases There are individual differences in the workers' reactions to occupational diseases, just as there are individual differences in reacting to the pollen of ragweed A careful checkup by the medical department may readily detect many individuals not suited to particular occupations An equitable transfer or other adjustment in such cases will tend to reduce occupational diseases Each industrial enterprise should study its experience and concentrate on eliminating the causes of its occupational diseases Close cooperation among the medical service, operating department, and engineering and process division is required to get effective results

[7] *Safety Subjects*, Bulletin No 67, U S Department of Labor, Washington, D C, p 27

Accident causes Table 47 1 shows the causes of accidents broken down into the headings of *unsafe acts, personal causes,* and *mechanical causes* The National Safety Council reports that about 87 per cent of all work accidents involve some unsafe act, and that 78 per cent have some mechanical or material cause In approximately 80 per cent of the unsafe acts, some definite personal cause was responsible Mechanical

Table 47 1 Causes (by Percentages) of Accidents *

Unsafe Acts		Personal Causes	
Unnecessary exposure to danger	26	Lack of knowledge or skill	48
Improper use of or unsafe tools	16	Improper attitude	31
Non-use of safety devices	15	Bodily defects	3
Unsafe loading or arrangement	10	No personal cause	18
Operating at unsafe speed	7		
Working on moving equipment	6		100%
Improper starting or stopping	5		
Other unsafe acts	2	Mechanical Causes	
No unsafe act	13	Hazardous arrangement	34
		Defective agencies	18
	100%	Unsafe apparel	15
		Improper guarding	9
		Improper light or ventilation	2
		No mechanical cause	22
			100%

* Source National Safety Council, *Accident Facts*, 1939 Edition, p 19

causes accounted for about 20 per cent of the total accidents The breakdown of the *unsafe acts, personal causes,* and *mechanical causes* in Table 47 1 indicates definitely the responsibility of management for proper selection, training, and discipline of employees, as well as management's responsibility for removing most of the mechanical causes The 20–80 ratio of accident causes has often been misinterpreted In most of the cases had either the mechanical factors been right or the employee been working safely the accident would not have occurred This fact shows that most of the accidents could have been avoided either by proper mechanical care or by the employees working more carefully By management's approaching the problem from both angles, a few metalworking companies have better safety records than department stores It can be done

Piece workers do not like to have their production slowed down even though the rate is supposed to compensate for the safe practice Some of the safety devices have been inadequately engineered and have placed an unnecessary burden on production On the other hand, careful engineering may change a hazardous operation to a safe one and increase

production at the same time Figure 47 7 shows a device that is carefully constructed for both safety and production The safety engineer should not sacrifice the workers' physical safety for increased production On the other hand, he should consider production requirements and harmonize the two The installation of an automatic feed, using strip stock,

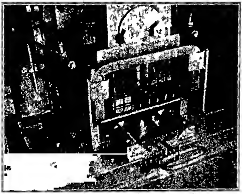
Courtesy, Junkin Safety Appliance Company Louisville

FIG 47 7 A guard that protects the worker and yet does not impede the output

not only raises the safety factor of a punch-press operation but also increases production The motion and time study department should be a strong ally of the safety department

Guards for machines Hand guardrails around a drinking fountain may prevent a worker from being hit by a truck passing in the aisle Point-of-operation guarding is coming to be of great importance, because although power-transmission machinery is usually well guarded, little has been done with points of operation, except the first two of the following three classes (1) accidents from flying particles, as emery and other abrasive wheels, (2) accidents due to contact with the moving parts of machines, as on punch presses, and (3) accidents due to kick-backs of work, or parts of the machinery which move flying through the air Ex-

amples of the third class are lumber kicking back from a circular saw and shuttles flying from the loom Figure 47 8 illustrates an effective point-



Courtesy General Motors Corporation

FIG 47 8 Basket guard for punch press, Ternstedt Manufacturing Company, Detroit (See handle for feeding parts into press)

of-operation punch-press guard Other types of guards (Fig 47 9) pull the worker's hands away from the descending tool

Courtesy The Powell Pressed Steel Company Hubbard Ohio

FIG 47 9 A safety device that pulls the hands away as the press trips

The great loss of eyes could easily be avoided by the use of goggles Goggles should be fitted by someone skilled in fitting glasses This person should appreciate what constitutes a fitted goggle, so that the wearer may,

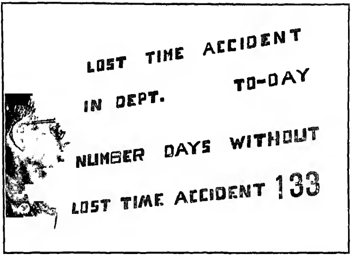
in addition to obtaining protection from the eye hazard he is compelled to encounter, be given the assurance of a feeling of security and comfort Proper clothing for the worker is almost as important as the guarding of machines The dress of an individual influences his attitude Safety garments tend to induce a safety attitude Accident prevention by making floors and walk-ways safe is a big factor in reducing the industrial-accident toll A study by the National Electric Light Association indicates that more than one-third of all falls occur on the level and on stairways, not from poles, scaffolds, or other equipment

Educating for safety An active safety committee (Fig 47 10) will work strenuously to have a better record than its neighbor, and, once

Courtesy Mechanics Universal Joint Division of Borg Warner Memphis Plant

FIG 47 10 A safety committee at work

aroused, the men learn how to put the doctrine across A competitive spirit (Fig 47 11) keeps the members of a department or plant safety conscious Vigorous and pointed safety bulletins should be abundantly posted and *frequently changed* Worker education in safe practices should be wisely planned and effectively executed (Fig 47 12) It never ceases, constant follow-up is required One of the most frequently overlooked persons is the oldtimer who has been around the shop for years and "should know" When he is transferred to a new job, he should be carefully checked regarding the safety factors Otherwise he is likely to assume that he knows what to do and unwittingly violates some sound practice, thereby hurting himself Older workers' records are good in terms of safety "Oldtimer," in the sense used here, refers to work experience,



Courtesy Mechanics Universal Joint

FIG 47 11 A member of the plant safety committee looks at the record of his department with pride

Courtesy E I du Pont de Nemours & Company

FIG 47 12 The foreman's responsibility is emphasized by regular conferences with each subordinate supervisor

not age Such a person may be 30 or 60 years old, but he should be given safety training whenever his job is changed

A well-edited employees' paper is an excellent medium for promoting safety and encouraging sanitation Nearly all plants which have safety programs of any size utilize safety posters of some kind The National Safety Council, Inc , has an elaborate poster service, and most of the casualty insurance companies include a poster service as one of the items in their workmen's compensation policies One of the direct results of safety education is to reduce the number of infection cases from accidents by having the injured worker report promptly to the dispensary for treatment A sympathetic doctor and nurse will work wonders in persuading men to come to the hospital for first aid, and first aid prevents infection Persuasion, as well as regulations, should be used for this purpose

Summary The achievements in accident prevention to date have been well summarized as follows

1 The accomplishment of numerous firms in every major branch of industry proves that disabling injuries can be reduced to a figure that closely approaches elimination

2 It pays to do so

3 The expenditures required are relatively small

4 Some degree of hazard is associated with every form of activity, therefore, the highest degree of accident elimination can be achieved only by careful, painstaking attention to safety in every form of activity carried on in any given establishment or undertaking

5 Accident prevention does not rest upon involved theory or special technical skill Instead it depends mainly upon safety mindedness by management and men Safety mindedness may be defined as "the ever-active attention to safety in every detail of each day's work "

6 If properly applied, the knowledge and resourcefulness possessed by every industrial organization, large or small, is adequate to bring its safety performance into accord with best practice and keep it there

7 Any management, regardless of the size of the establishment, type of industry or undertaking, or financial condition, can eliminate the majority of its work injuries

8 Each injury results from the combination of a physical hazard and human error The correction of either will usually prevent the injury but top safety per formance can be had only by eliminating or reducing every physical hazard to the maximum degree practicable and, in addition, using every feasible means of controlling all work habits and practices in the interest of safety [8]

[8] *Safety Subjects,* Bulletin No 67, U S Department of Labor, Washington, D C , pp 5–6

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